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ISMAEL. COUNT DE LESSEPS. FERDINANDE TOTOTTE). COUNTESS DE LESSEPS. MATHIEU.

THE PROPOSED PANAMA CANAL.—COUNT FERDINAND DE LESSEPS AND HIS FAMILY.—*London Graphic.*

THE PANAMA CANAL AND ITS PROJECTOR, FERDINAND DE LESSEPS.

Vicomte Ferdinand de Lesseps is certainly the very personification of indomitable energy and perseverance. Not content with having successfully canalized one isthmus in the face of every possible obstacle, geographical, political, and financial, he has now, in his seventy-sixth year, undertaken to execute a similar work across the Atlantic, which is arousing perhaps even a fiercer opposition than did his scheme to pierce the Isthmus of Suez. *On revient toujours à ses premiers amours*, and probably M. de Lesseps, when, more than half a century since, he was Consul in Central America, conceived the idea of uniting the Atlantic and Pacific Oceans through the Isthmus of Panama, more especially as at that time Humboldt was warmly advocating such an undertaking. It was curious also that when subsequently, in 1831, M. de Lesseps went to Alexandria as Consul General, he should find the idea of a canal across the Isthmus of Suez a fertile topic of discussion. As Egypt was nearer home than Panama, he turned his attention to the Old World first; but it was not until 1854 that his enterprise received the official sanction of Mehemet Said, with whom he was on intimate terms. The opposition M. de Lesseps received from Lord Palmerston and England, the obstructions placed in his way by the Sultan and the Porte, and the success which crowned all his efforts when the Empress Eugénie opened the canal in November, 1869, are too recent a matter of history to be repeated here. Having accomplished the great work of his life, M. de Lesseps determined to retire for a time on his well-earned laurels, and a few days after the inauguration of the Suez Canal he married a young Creole lady, Mlle. Hélène Autard de Bragard, by whom he has had the three children depicted on our front page (from photographs by Mora, 707 Broadway, New York), two boys and a girl, named respectively Mathieu, Ismael, and Ferdinande. Honors now began to fall thick and fast upon him. He received the Grand Cross of the Legion of Honor from Napoleon III., who had always befriended M. de Lesseps, for, on his mother's side, he was related to the Empress. England, which had so frequently opposed and scoffed at his enterprise, now tried to make amends by according him an enthusiastic welcome on his visit in 1870, when he received the Grand Commandership of the Star of India and the Freedom of the City of London. In 1878 the long discussed question of the Panama Canal came again to the fore, the Committee of Investigation handed over its concession to M. de Lesseps, the International Scientific Congress proclaimed that it could and ought to be carried out, and in December M. de Lesseps, his wife, and three children, started for the Isthmus to inspect the proposed route for himself. He returned, after some months' absence, thoroughly impressed with the practicability of the scheme. In a recent conversation with a *Times* correspondent he remarked, "I have greater confidence than I had for Suez. The Atlantic and Pacific breezes blowing down the Isthmus will make it the healthiest region in the world. We were there for months, my wife, children, friends, and laborers, and had not a single death." In the United States, where the Monroe doctrine of no European interference with the American continent is very popular, M. de Lesseps encountered the fiercest opposition, but nevertheless succeeded in gaining over a considerable portion of the community to his views, as has recently been manifested by the subscriptions to his scheme, and by the acceptance by the Secretary of the Navy of the chairmanship of the Panama Canal Company. Thus, if energy, perseverance, and confidence will carry the enterprise through all its difficulties, there is every chance of its success. That M. de Lesseps has all these in his favor there is no doubt. In the conversation above mentioned he concluded by saying, "Lastly, I may add that I have not against me that formidable obstacle, England. She is with me. This alone shows that the canal will be a fact, and I at once invite you to be present with me at the opening in 1887."—*London Graphic.*

BEGINNING WORK ON THE PANAMA CANAL.

On January 29, 1881 (says the Panama *Star and Herald*), the French steamer Lafayette arrived at Colon with Messrs. Armand Reclus, G. Blanchet, and about forty others who are to be employed upon the Panama Canal. They came to Panama the same day and were welcomed by the members of the Panama Commission. The canal headquarters will be in Panama, although Colon will be the main point for the distribution of supplies, etc.

The expedition is divided into distinct sections or departments. Mr. Reclus is the general agent, with full powers from the canal company. Mr. G. Blanchet is director of the canal works.

It is understood that the work is to begin at once. This will principally be in ascertaining the exact location of the canal; clearing away the timber, brush, etc.; arranging matters of titles for right of way, buildings, etc., and the general land grants of the company and other matters of a preliminary character. The organization of the company itself will not be fully completed for several months, and the construction of the machinery necessary to carry on the work will take considerable time. A year or more must elapse before the employment of machinery will be possible, and in the meantime the number of laborers needed will be small. The demand can be easily supplied at present. Any great immigration of men seeking employment in ordinary canal work is for the present unnecessary and undesirable.

The expedition is composed of the following departments: 1. The Superior Agency, having direct control and immediate supervision of the technical and legal matters as well as accounts. 2. Department of Real Estate. 3. Sanitary Service. 4. Work and Construction.

The Superior Agency is composed of the following persons: Armand Reclus, Commander of the French Navy, General Agent; Mr. Guignard, Secretary of the General Agency; Mr. Pedro J. Sosa, Civil Engineer, Chief of the Technical Department; Mr. Lucien Cazenave, Chief of a section in the Technical Department; Mr. Alfred Natanson, Engineer of Arts and Manufactures, Paris; Mr. Luis Verbrugghe, Chief of the Legal Service; Mr. Frederick Trufley, Attorney of the Court of Appeals of Paris.

Department of Accounts.—Mr. Henri Thromé, Cashier; Mr. Emile Le Mat, Accountant.

Real Estate and Sanitary Service.—Mr. Arthur Haril, Director in Panama; Mr Edward Carcenac, Agent; Mr. Maurice Hubert Delisle.

The physician in charge of the sanitary service will arrive by the next steamer. At present Mr. Frederick Pidoux, member of the Medical College of Paris, will fulfill these duties.

Department of Works.—The firm of Messrs. Couvreux & Hersent has been appointed by M. de Lesseps to complete the studies and carry out the works relative to the piercing of the Isthmus, and Mr. Gaston Blanchet is the representative of the above firm.

The staff comprises the following: Mr. Claud Clavenad, Director of the Technical Studies: Mr. A. Roux, Chief of the Mining Department, and Mr. Chamberlain Bey, Secretary.

Chief of surveying parties, Mr. G. Morel, engineer, having executed several important works in topography and triangulation; Mr. F. S. Weber, civil engineer; Mr. Fontan, engineer; Mr. P. Marolle, civil engineer; Mr. P. Van der Putte, civil engineer; Mr. C. Sonderegger, engineer.

CAPTAIN EADS' SHIP RAILWAY.

TERMS OF THE MEXICAN CONCESSION.

Mexico, December 21.—Captain Eads has completed his negotiations with the Mexican Government for the construction of his ship railway across the Isthmus of Tehuantepec, and has received from it the most liberal concessions which it has ever granted. It gives him the right to construct the ship railway on such line as he may determine, and he is to be entirely untrammeled in the plans and execution of the work, which is to be commenced within two years from the date of the grant and completed within twelve years. The concession grants a right of way across the isthmus half a mile in width, which width is increased, wherever stations are required, to one mile. It gives him the right to improve such rivers and harbors as he may deem proper, and to collect liberal tonnage tolls from vessels entering them. It permits him to collect $5 per cubic meter of the displacement of each vessel transported on the railway; the amount of tolls to be determined in the following manner: The greatest length and greatest width of the vessel, measured at the surface of the water, are multiplied by the greatest depth of immersion, and for each cubic meter, or fraction of a meter, contained in such parallelopiped of these dimensions, he is entitled to charge $5 toll. He is also entitled to charge $15 for each passenger on the ship, and one per cent. on the value of gold or silver coin or bullion or precious stones; and, in the event of such valuables not being declared to his agent, to collect ten per cent. on their value, and to detain the ship until the sum is paid. He is also entitled to such compensation as may be agreed upon between his agents and any vessels in transit for dockage, repairs, or cleaning, when needed by them, and to operate a telegraph line and an auxiliary freight and passenger railway line in connection with the ship railway. In addition, the government grants him a subsidy equal to 1,000,000 acres of public lands, to be located on the isthmus or elsewhere, in aid of the construction of a suitable harbor on the Pacific Ocean. It also gives him the right to consolidate the Tehuantepec Railway, now being constructed by M. Learnard and others, with the ship railway on such terms as may be agreed upon between them, and, in such event, the location of the Tehuantepec Railway may be altered as desired by Captain Eads.

The Tehuantepec Railway Company has a subvention, amounting to about $1,500,000, to be paid by the Mexican Government in custom house certificates, and has also a large land grant. In case of the acquisition of this railway its obligations to the Mexican Government are to cease and determine, and the subvention would then attach to the ship railway. The duration of the grant is ninety-nine years, at the termination of which the government is to take possession of the works and pay two-thirds of their value. Captain Eads, on his part, agrees to transport the ships, property, and troops of the Mexican Government without compensation during the existence of the grant. He has the right to export, free of all duties, all moneys required to pay dividends or to purchase materials of any kind for the use of the road, and likewise to import, free of duty, during the entire period of the grant, all materials, coal, and articles of every kind required for the construction, repair, and operation of the road.

The most remarkable feature, however, of this liberal concession is that which gives to Captain Eads the right to hypothecate the revenues of the road to any other government which he may select to aid him by money or guarantees in its construction. It gives to such government, in case of any default on the part of the company to such government, the right to intervene through the courts of Mexico and have receivers appointed to insure the faithful application of its revenues in accordance with the terms that may be agreed upon. No hypothecation or conveyance of the grant or of the works themselves or of the lands, however, can be made to any foreign government without invalidating the concession.

The permission to secure the co-operation of another government is intended by the Mexican Government to give to the United States the privilege of co-operating with Mexico in aid of the construction and control of the works, as this is regarded by the leading men in Mexico as the American route across the isthmus, and the one in which these two republics are most vitally and directly interested. The route across Panama, which is distant 1,200 miles from Tehuantepec, is called in Mexico the French or European route. Ships from New York to San Francisco would save about 1,500 miles by going by way of Tehuantepec instead of by Panama. The one route is through the Gulf of Mexico and the other through the Caribbean Sea. From the mouth of the Mississippi to California by Tehuantepec is 2,300 miles less than by Panama.

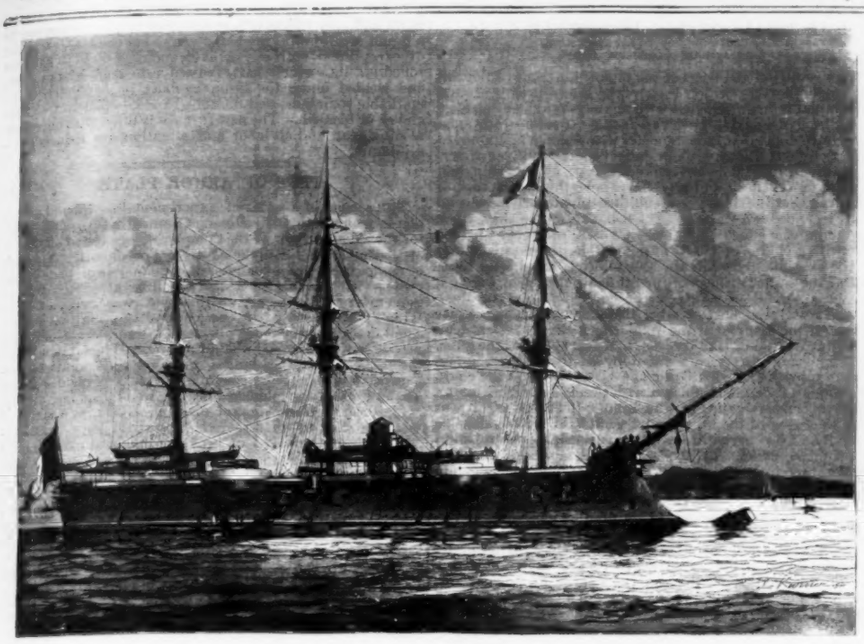
The tolls which Captain Eads is allowed to charge are nearly three times as great as those which are allowed in the Colombian grant to the De Lesseps party. This is done for two reasons: First, the railway across the Mexican isthmus will need to be about 112 miles in length, as against 45 miles at Panama; and second, the great saving in sea distances in favor of Tehuantepec will justify much higher rates of toll.

The tolls allowed Captain Eads, even assuming that the actual tonnage will be only one-third as much as that estimated by the Paris Convention, will, it is thought, insure such profits as will enable him to secure sufficient private capital to construct the railway. A canal at Panama, at the lowest estimates that have been made for it, will be largely more than double the cost of the ship railway at Tehuantepec, which Captain Eads estimates will be $75,000,000. He, however, proposes to give to the United States the right to lower these tolls to any point deemed advantageous to the interests of American commerce, and to transport its ships, property, officers, and soldiers gratis, on condition that it will guarantee six per cent. dividends on $50,000,000 of the stock of the company. He insisted on the insertion of a clause which would permit the United States Government to lend its aid to this work, and declared to the President and Cabinet of Mexico and to the leading members of its Senate and House that such a clause would be looked upon by the United States as an evidence on the part of Mexico of confidence, likewise as an evidence and a desire to cultivate the kindliest relations with the United States. The greatest delay in obtaining the concession resulted from Capt. Eads insisting that such a clause should be inserted in the grant, and from his declaration that he would not consent to appeal to capitalists or to any other government without first giving to the United States this opportunity.

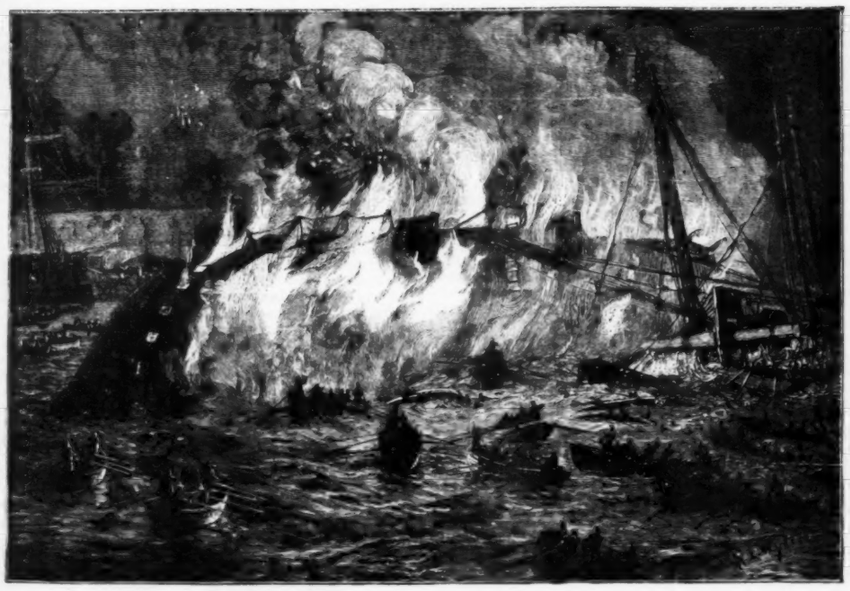
The utmost unanimity prevails in this country with regard to the practicability of the ship railway. Not a word has appeared in any of the papers of Mexico expressing a doubt of it, nor have I heard such doubt expressed by any one in the country. The people seem to accept the success which has attended the engineering works of Captain Eads as an ample guarantee of his ability to carry out what he proposes, and, while his reception here has been devoid of any theatrical display, the manner in which he has been received and treated by the Mexican Government and people has been a source of the liveliest gratification to American residents in Mexico. At his request a costly expedition, comprising about fifty individuals—engineers, assistants, laborers, and soldiers—to assist him in making a survey of the isthmus to determine the most practical route for the ship railway, has been prepared by the Mexican Government, and has started for the isthmus. This commission is under the direction of the eminent civil engineer, Francesco de Garay, who is in charge of the drainage of the Valley of Mexico, and who was commissioned to represent the Mexican Government at the Paris Canal Convention. He is directed by the government to assist the engineers of Captain Eads in the instrumental survey of such routes as he may designate. Messrs. Williams and Corthell will direct the survey during the absence of Captain Eads, who has started with the expedition to the isthmus to inspect the rivers and harbors, and give the party such instructions regarding the work as he may deem necessary. As an additional evidence of the respect of the government for Captain Eads, it has ordered one of its war vessels, the Independencia, to take him from the isthmus to the port of New Orleans, on his way to Washington.—*Cor. N. Y. Tribune.*

THE DE BAY PROPELLER.

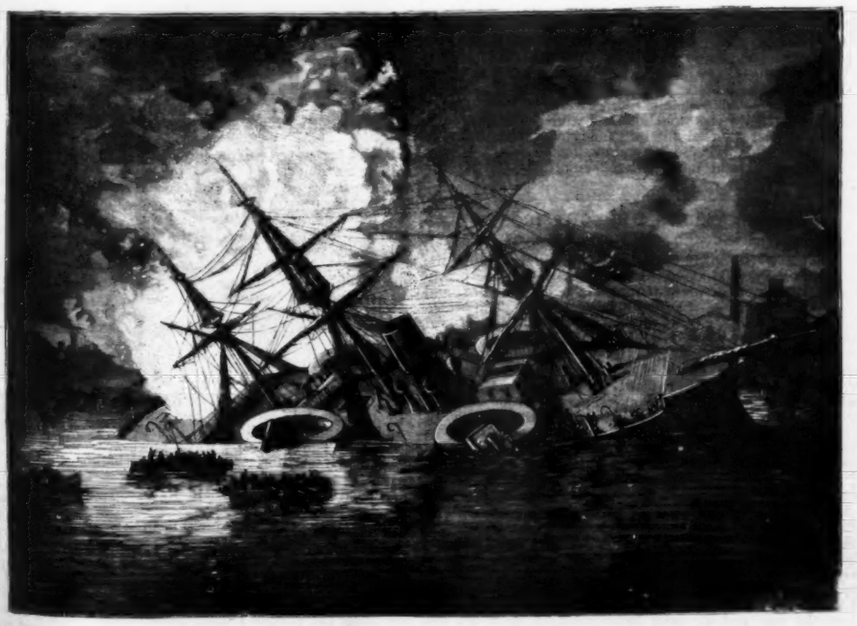
We have just received a copy of a report, by Mr. Hiscock, of the voyage of the S. S. Cora Maria from Cardiff to the Danube and back to Malta, dated December 6, 1880. It will be remembered that we illustrated the machinery of this ship in our impression for August 20. Mr. Hiscock accompanied the ship on her voyage. Mr. Hiscock writes: "The run to Alexandria was rather disappointing in one respect, viz., in the actual time taken for the whole journey, but this is easily accounted for by the fact that the steering and courses were very bad, principally due to the large aperture left over the propeller, and the bluff lines of the vessel; also to fogs and frequent stoppages, and the loss of time from these causes may be put down at a very minimum of one and a half days. For when going along the land in as straight a course as could be kept, the speed, as measured from point to point, was never less than 9¼ knots, and sometimes reached 9½ knots, unassisted by winds or currents, against 8 knots under similar circumstances with the old screw, equivalent to a saving of 35 per cent. Then the consumption on the whole voyage was half a ton less per day, or 5 per cent. saving, making a total of 40 per cent. saving. One great feature of the propeller was fully brought out on this run, viz., its firm grasp on the water in a heavy seaway, for on August 30, with a strong head wind and sea and considerable pitching, the distance run in a straight line was 183 miles in twenty-four hours, the revolutions being slightly reduced, but the slip not increased, and on 2d September, with a heavy sea running abeam, causing the ship to roll very much the distance run was 208 knots. In Alexandria the aperture was covered up, with the result of greatly improving the steering, and on the run to Constantinople in ballast, with the propeller partially out of water, the average speed for the whole voyage of 760 miles was 9 knots, against strong head winds most of the way, amounting at one time to a gale; against strong currents in the Dardanelles and Sea of Marmora, and including ten hours of steaming slowly, while the average speed all through the Dardanelles, from Tenedio to Gallipoli, was 10 knots against the currents. The run from Constantinople to Sulina gave an average of 10¼ knots for twenty-five hours against slight southerly currents in the Black Sea. The total consumption from Alexandria of mixed Welsh and Newcastle coals, principally the latter—which is inferior to the former—was 10 tons per day. With the old screw it has always been between 11 and 12 tons for a speed of 8½ knots in ballast. The saving on this voyage is extraordinary, amounting to 50 per cent., but this quite agrees with the results of the trials at Cardiff. The run loaded from Sulina to Malta was also highly satisfactory, although not showing such a great saving as the run in ballast. It was not intended to go at full speed, but at a rate as near as possible to that with the old screw, or but little faster, in order to show the actual quantity of coal saved; but as the coal taken in at Sulina was of a very inferior description, and so dusty and dirty that on the first two days the steam could hardly be kept up at all, we were obliged to resort to indicator diagrams to ascertain the saving in power. These showed the actual saving in cubic feet of steam used to be 23 per cent. while running at 8½ knots along the land uniformly for twenty-four hours, and the extra half knot over the old screw gives an additional 18 per cent., making 41 per cent. total saving; and this result can be obtained in two other different ways, viz., from the indicated horse power and from the known consumption per indicated horse power from the previous two runs. It was still further corroborated upon arriving at Malta, upon measuring the coal consumed, which was found to be from 9¼ tons to 10 tons per day, certainly not equal to more than 7 tons of good coal, as it made double the quantity of ashes and clinkers, the firebars being constantly clogged by the melted sand running through them. The propeller was again severely tested on this run, for after passing Cape Matapan, with a very strong head wind and sea, and the ship pitching considerably, so as to lift the propeller out of the water with the loaded ship, the total distance run in twenty-four hours was 196 knots. After leaving Malta the boiler tubes began to give way, the boiler leaking very badly, causing stoppages and slow speeds, and it was finally decided to put in at Algiers for tube stoppers. As this would detain the ship several days, and all hope of obtaining definite comparative results from the consumption of coal, with the boiler out of order, had to be abandoned, and having no doubt of the gearing being capable of bringing the ship safely home, I decided to leave the ship immediately, so as to be prepared to make some alterations in the gearing upon her arrival. The gearing has proved unsuitable in the crank arrangement and requires too much attention. It had been designed to meet the many objections put forward against toothed wheels, but as these



THE FRENCH IRONCLAD RICHELIEU, AT TOULON.



BURNING OF THE FRENCH IRONCLAD RICHELIEU, AT TOULON.



SINKING OF THE FRENCH IRONCLAD RICHELIEU, AT TOULON.

wheels have proved themselves immensely strong and capable of bearing the heaviest strains that could be put upon them, and still working smoothly and steadily, requiring no attention whatever, it is now proposed to substitute a much simpler arrangement of wheel gearing, which will be more suitable under all circumstances, stronger, cheaper, and always reliable, requiring no extra labor or attention, and, in addition to its other advantages, occupying but one-fourth the space required for the present arrangement. Taken altogether, the voyage has been highly encouraging. We have gained a large amount of experience, which will be invaluable in the future, and we have obtained results which demonstrate beyond all doubt the immense superiority of the propeller, especially in a heavy seaway; and there is no doubt that these results can be continually maintained with the proposed alteration in the gearing. Although it has always been a prominent feature of the propeller to improve the handiness of a vessel, it is worthy of mention how the Cora Maria steamed from the harbor into the basin, and thence into the floating dock at Alexandria, without a single rope being put over her side, or any external assistance whatever. Also how she steamed up the narrow and tortuous Sulina branch of the Danube, fifty miles in length, against a strong current at full speed, without a single stop, and without once going near the banks at any of the sudden turns—a most unusual feat."

Since the above was written the Cora Maria has arrived safely in England, and has gone to Bremen; on her return she will be fitted with bevel steel gear, which ought to get rid of the difficulties encountered with the existing gear, which were brought on entirely by the working of the ship when heavily loaded in a seaway. It will be seen that the results confirm the opinions which we have expressed concerning the merits of this invention.—*The Engineer.*

For illustrations of this peculiar propeller, see SCIENTIFIC AMERICAN SUPPLEMENT, No. 250.

CLYDE SHIPBUILDING.

THE return of ships built on the Clyde during 1880 seems to prove that there has been a genuine revival in this important branch of industry. With the exception of the year 1874, when the number reached the maximum, the figures for the present year are the largest ever known in the history of the trade. In 1874, 262,330 tons of shipping were launched, and the present returns are only 25,851 tons below these figures, while they are 61,829 in excess of the returns for last year, 14,226 tons above 1878, and 66,869 over the figures for 1877. The year closes with a large amount of work on hand and good prospects for the future. Most of the yards are well placed for work, while one or two of the firms will not be in the market for some time. During the year the various firms engaged in shipbuilding on the Clyde launched 209 vessels, of an aggregate tonnage of 236,578 tons, as compared with 171 vessels and 174,750 tons during 1879. Taking the principal firm on the river, the figures compare favorably with last year; thus, Messrs. John Elder & Co., who headed the list last year with a total of 16,895 tons, have this year secured first place with the unusually large total of 33,262 tons; Messrs. Elder & Co. have in course of construction vessels representing fully 24,000 tons, while they are making engines of 7,000 indicated horsepower for the Russian war vessel Peter the Great. Messrs. Alexander Stephen & Sons launched last year 16,305 tons, this year 19,005 tons; Messrs. William Denny & Brothers launched last year 16,236 tons, this year 18,112 tons; Messrs. D. and W. Henderson & Co. launched last year 3,306 tons, this year 12,341 tons; Messrs. A. & J. Inglis completed last year 4,179 tons, this year 10,735 tons; and Messrs. Aitken & Mansel launched last year 2,009 tons, this year 10,000 tons. The number of vessels built of steel during the year reaches an aggregate of 40,688 tons, against 28,808 tons during 1879. —*London Times.*

THE DESTRUCTION OF THE IRONCLAD RICHELIEU.

ON the 29th of December, 1880, a fire was discovered on board the French ironclad Richelieu, which was stationed as one of the reserves at the Toulon Navy Yard. The civil and military authorities assisted the commanding naval officers very promptly, and the engines of the fire department and of the vessels in the yard soon began to play upon the burning vessel. After four hours of hard labor it became evident that the destructive element could not be checked, and the water gates of the Richelieu were opened, upon which the vessel immediately began to incline toward the right side. At this moment, which is represented in one of the annexed cuts, the larboard cannons separated their cables and were thrown toward the starboard with an enormous force, and, striking the cannon of the turrets, precipitated them into the water. Finally the Richelieu sank, and between 8 and 9 in the evening preparations were commenced for raising the vessel.

The Richelieu is one of the five strongest ironclads of the French navy, and, like the Colbert, is constructed of wood, with an armor 8½ inches thick at the water line in front, and 7 inches at the rear.

The length of the vessel is 321½ feet at the water line, 57 feet beam, and 41½ feet depth. This enormous naval machine has a draught of 33½ feet, and the displacement is 8,791 tons.

THE BURNING OF THE RICHELIEU.

Early on the morning of the 29th December, 1880, the town of Toulon was startled by the booming of cannon and the violent ringing of the tocsin. On the alarmed inhabitants turning out to inquire the reason it was found that the Richelieu, one of the most powerful ironclads of the French navy, was on fire. All the resources of the arsenal were at once brought into play, innumerable pumps, both ashore and afloat, poured streams of water upon the flames, but, notwithstanding every effort, the fire continued to gain such ground that at last the authorities determined to sink the vessel. Accordingly the ports were opened, and the Richelieu began to settle down, leaning somewhat to starboard. Suddenly the lashings of her port guns gave way, and the pieces rolled over to the right side, with a terrible noise, causing the vessel to lurch still further in the same direction. Her masts caught in the rigging of the Forbin, which was close by, and in heeling the Richelieu also swamped a barge filled with firemen. Ultimately she sank without any further damage. The vessel herself is not thought to have been very greatly injured, and it is expected that she will be shortly raised and refloated. For some days, however, the divers were unable to enter the vessel, as the fire was found to be still smouldering, and there was considerable danger of suffocation, but later on some of her small guns were recovered. The Richelieu was launched in 1873, and was

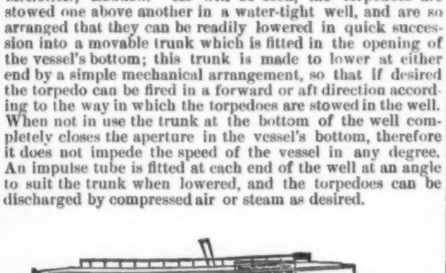
ranked in the first-class. Her tonnage was 8,400, and she carried twenty-one guns. Of these six of 23 tons were in a central battery, and one of 15½ tons in each of the four turrets. How the fire broke out is not known.—*London Graphic.*

The armament consists of six 10½ inch guns and four 9⅜ inch guns, and besides these the forecastle is provided with one 9⅜ inch gun and with ten 4⅞ inch guns.

The vessel is propelled by double Woolf engine of 4.000 horse power normal. The speed attained varied from eleven to thirteen knots. The sum required to raise the ship is estimated at two millions of francs (about 400,000 dollars.

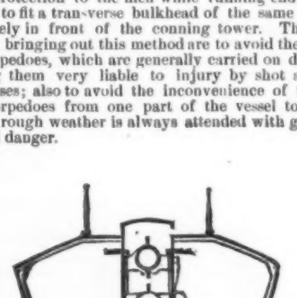
TOWING AND DISCHARGING TORPEDOES FROM TORPEDO BOATS.

The accompanying engravings illustrate a first-class torpedo boat fitted with an improved method for stowing and discharging torpedoes, invented by Mr. J. E. Atkinson, M.I.N.A., London. As will be seen, the torpedoes are stowed one above another in a water-tight well, and are so arranged that they can be readily lowered in quick succession into a movable trunk which is fitted in the opening of the vessel's bottom; this trunk is made to lower at either end by a simple mechanical arrangement, so that if desired the torpedo can be fired in a forward or aft direction according to the way in which the torpedoes are stowed in the well. When not in use the trunk at the bottom of the well completely closes the aperture in the vessel's bottom, therefore it does not impede the speed of the vessel in any degree. An impulse tube is fitted at each end of the well at an angle to suit the trunk when lowered, and the torpedoes can be discharged by compressed air or steam as desired.


VESSEL UNDER WAY WITH WELL CLOSED
VESSEL WITH TRUNK LOWERED FOR FIRING TORPEDO FORWARD
TRUNK LOWERED FOR FIRING AFT
DECK PLAN SHEWING WELL

In a larger class of boat two such wells could be fitted with advantage, one being arranged for firing the torpedoes ahead, the other for firing them astern. By these means a very formidable vessel would, it is claimed, be obtained. The arrangement is also well suited for light draught gunboats, such as those recently built for the Chinese waters and other places, which boats, if so fitted, would become very destructive vessels.

The advantages claimed for this method are, as will readily be seen, that everything is under cover and out of sight of the enemy, and that none of the crew need be exposed while in action, as all the arrangements are worked from below the deck; that nothing can be seen of the preparations being made for discharging the torpedoes, or the direction in which they are traveling; that a torpedo may be discharged toward an object while the head of the vessel is in an opposite direction; that a torpedo boat has not to go out of action to prepare for discharging a second torpedo—during which time the chance of attack might be lost—and that the risk of a sea or floating object striking the torpedo as it is about to enter the water from the deck is entirely avoided, as also the risk of damage to the appliances and torpedoes by collision, they being well within the body of the vessel. To protect the men and torpedoes from the effects of the Nordenfeldt and other such guns, it is proposed to make the well of Bessemer steel plates of sufficient thickness to resist the shots, the gear being arranged to work on either side of the well, and thus enable the men to work out of danger, and as a further protection to the men while running end on, it is proposed to fit a transverse bulkhead of the same strength, immediately in front of the conning tower. The objects sought in bringing out this method are to avoid the exposure of the torpedoes, which are generally carried on deck; thus rendering them very liable to injury by shot and many other causes; also to avoid the inconvenience of transporting the torpedoes from one part of the vessel to another, which in rough weather is always attended with great difficulty and danger.



Another great object is to dispense with the present method of discharging the torpedoes from fixed and movable tubes on deck in the bows of the torpedo boats, as they are liable to become damaged, and in case of the slightest collision would be likely to render the boat useless for the purpose of attack, and cause it to retire from the scene of action; and a further advantage is gained by not allowing the enemy to see the torpedo discharged, whereby he could ascertain the direction in which it was traveling, and in all probability enable him to get out of the line of fire.

In cases of necessity, or for the purpose of deceiving the enemy, the proposed arrangement could be fitted to almost all vessels, and in some the well could be fixed in a diagonal position, so as to fire a torpedo at a vessel while passing unsuspected beside her.—*The Engineer.*

THE TRIALS OF THE INFLEXIBLE GUNS.

TRIALS OF GIGANTIC GUNS.

The results of the trials of the eighty-ton guns of the turret ship Inflexible, which took place December, 1880, and which had been anticipated with anxiety by the authorities, have been deemed highly satisfactory, demonstrating, as they have done, that these monster weapons can be employed under any conditions without danger to the hull or superstructure of this the latest completed type of war ship, and the Lords of the Admiralty have now the satisfaction of knowing that the heavy expenditure upon this wonderful craft has not been wasted. The behavior of the ship, when sustaining the effects of a discharge of a projectile of 1,700 lb., with a charge of 450 lb. of powder, has been satisfactory in the extreme, for while she seemed to be lifted, as it were, out of the water, articles of furniture in the cabin were not displaced.

The vessel was, on December 16, taken some ten or twelve miles off the east end of the Wight, and shortly after noon a scaling charge of 130 lb. was fired from each of the guns. The guns and turrets are worked by hydraulic gear, manufactured by the Elswick Ordnance Company, and the colossal weights were manipulated with precision and without a hitch or misadventure of any kind. It had been thought that the firing of the heavy guns would do serious damage to hull and superstructure, and perhaps cripple the splendid machinery, which, by the way, worked very smoothly. When, therefore, the word was passed around that the gun in the fore-turret was ready for firing, the upper part of the ship was soon cleared, a few only proceeding to the citadel, from whence the gun was to be fired by electricity. The suspense of the delay in making the first experiment was painful to the people under hatches, who were naturally speculating upon the consequence of the shot. The projectile weighed 1,700 lb. and the charge of powder was 300 lb. The vibration produced by the first shot was not nearly so severe as many had expected. The smashing of glass was trifling, and as to the injury to the hull and superstructure there was none. The next two shots were fired from the after turret, and in the course of the afternoon nine shots, the charges being eventually increased to 400 lb., were fired. The experience of succeeding discharges was almost the same as the first, the first seven shots being fired horizontally and the other two at a slight depression. Some shots were fired on the beam and some just before it. The experiments tended to show that the guns can be worked under any conditions without danger to the ship or the crew. No casualty of any kind occurred during the day, and at 6 P.M. the Inflexible returned to her anchorage at Spithead.

On the 17th of December the trials were concluded off the Isle of Wight. The ship got under way shortly before nine o'clock, and steamed out to the back of the island some fifteen miles. The weight of the projectiles then used was 1,700 lb., and all the charges were of 450 lb. Twenty shots were fired with one gun, two guns, and three guns simultaneously. The direction of the firing varied from a beam to 75° before and abaft the beam. The results were satisfactory; the officers of the dockyard, indeed, express their surprise, the defects being next to nothing and confined to the starting of a few bolts. All sorts of vessels, with all sizes of guns, from 25 tons upwards, have been to Portsmouth for trial, but the Inflexible is said to have stood the test even more satisfactorily than some ships with lighter ordnance.

The Inflexible concluded her present series of tests on Saturday by a measured-mile trial of her machinery in Stokes Bay, the mean of four runs giving a speed of 14·286 knots per hour. During the runs the steam pressure in the boilers averaged 57·57 lb. per square inch; the revolutions of the engines were 77·43 starboard and 76·50 port per minute; and the mean pressure in the cylinders, starboard high 26·5 lb., starboard low 8·575 lb., port high 27 lb., port low 8·35 lb., giving a total indicated power of 7,860·78 horses. The day was very favorable for a full-speed trial, the force being only 2 and the sea smooth. The speed realized on the original trials, which were, however, made on nine inches less mean draught, was nearly half a knot greater. But it must be stated that on the previous occasion the bottom was quite clean, while at the trial of Saturday, the 18th, the diver reported the wetted surface to be covered with a thin coating of slime, which would necessarily tend to diminish the speed. The ship at the former trial was fitted with two bladed screws of coarse pitch, the vibration arising from which was so great that the stern of the vessel was severely strained. The trials of Saturday were made with four-bladed Griffith's propellers, the diameter and the pitch being both considerably reduced. The result showed that the vibration was greatly lessened. The *maximum* power was not developed by the engines, which was hardly to be expected, as steam had been up in the boilers for several consecutive days during the gunnery trials. The machinery gave perfect satisfaction, and it is expected that, under similar circumstances as regards boiler tubes and hull, the original speed will be maintained, if not exceeded, by the present screws. The *maximum* temperatures were 83° in the engine-rooms and 128° in the stokehole, and were considered satisfactory. After the trial the Inflexible steamed into harbor, and will be taken in hand for completion.

The electric light has answered admirably during the trials.

STEEL VERSUS WROUGHT IRON.

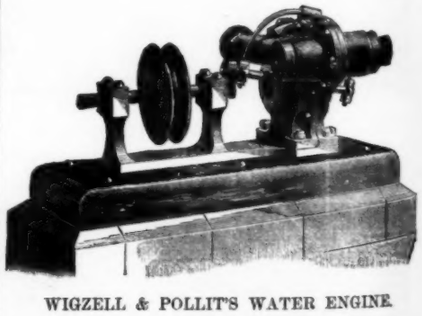
The officials of the Royal Gun Factories, Royal Arsenal, Woolwich, have for some time past been investigating the merits of the new kinds of steel as a material for the manufacture of guns, and various samples have been repaired and tested to aid in the solution of this problem. The probability is that wrought iron, which is at present the material almost invariably employed in the production of British ordnance, will have to yield to the superior claims of a suitable description of soft steel, the peculiar fitness of which for the purpose is due to its great strength and extensibility without the sources of weakness inseparable from wrought iron owing to the existence of lamina and the presence of cinder. Practically, this steel is a wrought iron without its faults, uniform in texture and strength; and made by the process of melting instead of puddling. Furnaces of the highest attainable temperature are essential for this process, and in the Royal Gun Factories the production of soft steel from the open hearth is accomplished by the use of Price's retort furnace, of which class a new one, equal to the production of from seven to ten tons of steel, has just been started with the most perfect success. These furnaces are regenerative, taking up and returning to the furnaces the escaping products of combustion, and the surplus caloric which might otherwise be wasted is further employed to heat the coal and air prior to combustion, by which system of reheating the temperature is regulated equal to the rapid and easy fusion of wrought iron and its suspension in a liquid condition in the bath. Steel has thus been created of exceptional softness, in evidence of which it has been rolled out into 4-inch bars, twisted into coils at the mills, and welded under the steam hammer into cylinders of remarkable soundness and ductility, and completely free from cinder or blemish. The new furnace is fitted with automatic feeding gear, and all labor and attention are reduced to a minimum.

TEST OF ARMOR PLATE.

The second of a series of experimental compound armor-plates, manufactured by Messrs. Cammell & Co., of Sheffield, for the side of armor of the Conqueror, was tested on the 7th of December, on board the Nettle at Portsmouth. The basis of comparison was a compound steel and iron plate of the ordinary rolled pattern, which was fired at on the 28th of September. The result of this test was reported to be "highly satisfactory" by the Admiralty authorities. Eight small cracks were opened during the ordeal, one of which was more pronounced than the rest. When taken from the bulkhead three bulges marking the points of impact were visible, but without any cracks being discovered on the back of the plate, while the wood backing did not exhibit the slightest signs of damage, so that, as a matter of fact, the skin of an armored ship would have passed unscathed from the blows of heavy ordnance at exceptionally short range. The armor tested on the 7th inst. had been cut from the original plate, and was in most respects precisely similar. It measured 7 feet three inches in length, 6 feet in height, and 11 inches in total thickness, of which the hard steel face measured 2¾ inches in depth. The experience derived from previous trials had shown that the hard face might be safely reduced without detracting from its efficiency in breaking up the projectiles, the difference in thickness being given to the iron backing to secure additional toughness. The weight of the plate was eleven tons, and it had been bent vertically and horizontally in order to suit the double curvature of the ship's side. But while the former plate was held to have successfully passed through the ordeal the Admiralty were desirous that a series of experiments should be prosecuted by Messrs Cammell, with a view of ascertaining whether any change in the processes of manufacture would reduce the cracking under fire. Accordingly, the plate tested on the 7th inst., after being formed and rolled in the manner hitherto adopted, had been annealed in a furnace heated up to a red heat for the space of six hours, and then bent and cooled in dry sand. The plate was fired at three times by the 12-ton 9-inch M.L. gun, with charges composed of 50 lb. of pebble powder, and with Palliser chilled projectiles, weighing 258 lb., at a range of ten yards. The rounds were delivered triangular fashion, a couple of feet apart. The difference in the comparative results was apparent. The cracks which were developed, though more numerous, were of a much finer character, none of them exceeding in importance what are called hair cracks. The projectiles were broken up in each instance, the utmost penetration ranging from six to seven inches.

WATER ENGINE.

The annexed engraving shows a perspective view of an excellent water-motor, known as Wigzell & Pollit's water engine. As will be observed, it is a very compact affair. In the crank there is a shaft or arm which passes through a ball having a circular plate upon it. This plate moves upon two cones, the water comes in in the shape of a wedge, and travels round until it gets to the outlet. This action takes place on both sides, thus the power is transmitted to the crank through two stuffing boxes. On the top there is a guide block connected to a bow on the center shaft, which prevents the plate revolving, and also takes the weight off the working parts. There is no slide valve or piston, and no friction, except through the two stuffing boxes. There is



WIGZELL & POLLIT'S WATER ENGINE.

one inlet for water, which is divided into two outlets, by passing on each side of the moving plate. It is very simple, and is quite a new principle of motor. It is well adapted for working organs, lathes, sewing machines, and the like. It is quite silent in its action, and there is no dead center. At the late Engineering Exhibition it was working with only 5 lb. pressure upon a 4-inch engine, ¼ horse-power, and the power it gave out was very remarkable. This engine would seem to have a good future before it as regards the applications to which we have referred, as well as for use in lieu of water-wheels and turbines. It is being introduced by Mr. E. E. Wigzell, of 37 Walbrook, London.

STRUCTURES IN THE SEA.

Simple oscillating waves, such as vessels encounter at sea, of course are neither broken nor reflected by the vessel, nor would they be by a lighthouse in deep water on slender columns. The oscillating wave, however, is converted into a wave of translation on coming into shallow water, and it is this dangerous wave which effects the destruction of marine structures. A wave of translation has a velocity of transmission slightly greater than the velocity acquired in falling half the depth measured from the wave crest. It has a length equal to about 70 per cent. of the circumference of a circle of a radius equal to the depth of the water in repose plus half the height of the wave crest, and its period is that of the oscillation of a pendulum equal in length to half the preceding radius. When a series of waves advance in shallow water the periods remain constant, but the lengths become shorter and the slopes steeper. Both theory and ob-

servation indicate that a wave must break when the depth of water is reduced to that of the height of the wave crest. Take for example the case of a pier running out perhaps a mile from shore into 36 ft. of water and exposed to rollers 20 ft. in height. The velocity of transmission of such waves would be about

$$=\sqrt{g\left(36+\frac{3\times20}{2}\right)}=46 \text{ ft. per second,}$$

or more than 30 miles per hour, and the length of wave would be about

$$=\sqrt{2.\pi\left(36+\frac{20}{2}\right)}=204 \text{ ft.}$$

The pressure on the end of the pier, supposing the waves to be reflected, would be equal to that of a column of water double the height of the wave, or about 24 cwt. per square foot. This theoretical result might have appeared improbably great had it not been verified many times by experiments with marine dynamometers. Assuming, for instance, one of the largest Atlantic liners to be stranded and exposed broadside to the rollers, the pressure upon the vessel from the reflected waves would be equal to about four times her displacement, or say, from 25,000 to 30,000 tons. It is small matter for surprise, therefore, that none but a few small and solidly constructed vessels withstand such an ordeal. Even riding at anchor, bow to waves, the risk is great. An ordinary 1,000-ton ship, for example, would have a midship section of about 360 square feet, and to hold that extent of flat surface square to the 20 ft. rollers would, at the rate of 24 cwt. per square foot, require a force of 432 tons, whereas her cables of 1¾ in iron would be tested up to 55 tons only. The resistance of the bows of such a ship would, however, be only about one-tenth of that of the flat surface, or in other words, the strain upon the cable would theoretically be about 43 tons. At the Cape and elsewhere, where harbors have yet to be constructed, such vessels have to encounter rollers of the class described, and although of course two cables are always out, the margin of safety is not sufficient to make the captains entirely happy.

A greater pressure than 24 cwt. has moreover been actually measured at many places, and from a mass of data of various kinds it is very generally agreed that the blow from the waves in a very exposed situation may be equal to the statical pressure of 100 ft of water, or about 3 tons per square foot. Stevenson has frequently recorded the latter pressure with his marine dynamometer, and has noted cases at the Bell Rock lighthouse and elsewhere, where the water during a ground swell without wind was projected to a height of over 100 ft. Waves about 40 ft. high have been observed to strike the Wick breakwater, and according to the laws of dynamics to reflect such a wave would require a pressure equivalent to double the height, or 2½ tons per square foot. Balks of timber 20 ft. long by 12 in. square have frequently been broken by the waves at Hynish harbor, Argyleshire, and the distributed breaking weight for these balks would be from 20 to 25 tons, or at the rate of from 1 to 1¼ tons per square foot. Stevenson found that a dynamometer placed on a pile a little in advance of a solid wall recorded about half the pressure of that given by another dynamometer on the wall itself, and there are sound theoretical reasons for the assumption that an isolated pile such as the screw pile supports of a promenade pier or lighthouse would not be exposed to a third of the pressure per square foot that would be exerted on a continuous wall similarly situated. Nevertheless there are not wanting instances even of 4 in. square bars, as at the Dhu-Heartach lighthouse, being twisted and torn by the waves, though placed on a rock standing 20 ft. above high water.—*Engineering.*

ELEVATED CABLE RAILWAYS.

M. F. WEIDKNECHT, a French engineer, is constructing a very useful sort of elevated railway, which affords an economical means of transporting coal, lignites, coke, ores, limestone, etc., to a considerable distance, and which has already been adopted at a great number of the mines and forges of Spain, Sweden, Russia, Italy, and Germany. The great advantage of this aerial road is that it is entirely independent of the nature of the ground over which it is constructed; so that the greatest obstacles presented by nature—such as ravines, rivers, and mountains—oppose no difficulty in the way of erecting it. The road, properly so called, is formed of two round iron cables, running parallel, and manufactured especially for the purpose. These cables are welded at every 120 or 160 feet, and fixed at certain points to the extremity of cross pieces supported by posts. They are solidly anchored at one end of the road, and kept taut by a counterpoise acting on a pulley at the other terminus. The posts, which may be of either wood or iron, are planted at distances of from 90 to 100 feet (or, in some cases, 300) apart. At the two termini are situated abutments, formed of bars of iron, to prevent the cars from running off the cable. The cars are constructed very strongly of either iron or steel, and are supported on the rail by two channeled wheels, fixed in the same plane and on the same side of the cable. This arrangement of the wheels in the plane of the center of gravity of the car permits them to pass over the supporting cross pieces without difficulty. The cars are put in motion by means of endless cables, which run from one end of the line to the other, parallel with the carrying cables and beneath them. The hauling cable is put in motion by a crank stationed at one terminus, and winds around a windlass stationed at the other. This wire is supported along the roadway by the cars themselves, which carry it by means of a small side pulley. As soon as a car arrives at a station, for example at the one where it is to be unloaded, it automatically drops its cable through the striking of a tappet against an iron bar. The hauling cable continues moving until a workman causes the car to pass on a rail over the abutment in order to unload it. Then he attaches the hauling cable, and the empty car returns to the loading station. Shortly before arriving there it is detached from the hauling cable and manipulated in the same manner as it was at the other terminus. It can be easily seen that this system is very convenient and very economical, especially for use over very irregular tracts of country, where, to build an ordinary surface railway, it would require large detours, extensive fillings and gradings, and other costly work. These elevated roads have already greatly facilitated exploitations that were formerly difficult, and, in some cases, judged impossible. Neither winds, rains, snow, nor hail can affect them, nor arrest their operation; and it is this that renders the system incomparably superior to all other methods of transportation. More than five hundred lines are in operation in various parts of Europe, some of them of considerable length.

EXTINGUISHING FIRES IN COAL MINES.

To the Editor of the Scientific American:

In view of the recent and unsuccessful attempts to extinguish such fires, I would offer the following remarks, with the hope that the little weight they possess may contribute to the prevention of further loss of time and money in the mistaken application of steam, carbonic acid, etc., to such purposes. The attempt to extinguish fires in coal mines by means of steam or carbonic acid must, when the fires are extensive, generally prove a failure, from the fact that, even after months of treatment, and allowing that combustion is stopped during the time, there will remain sufficient of the heat previously generated to set fire to the coal when the oxygen of the air does find access. There is, if I mistake not, in successful operation, for the manufacture of gas, a process in which steam is forced through hot coal and supports a combustion of its own decomposition. If it will do this in the gas furnace, why not in the mine? It must be evident to all that considerable time will be required to cool off the large masses of coal and rock in the case of mine which have been burning for months, and are on fire over considerable extent. Deep in the earth, there is little chance for the heat to escape, and, unless the temperature can be reduced below six or eight hundred degrees, combustion will recommence when the air is admitted. The only method occurring to me that appears at all practical is to corral the fire with a ditch, and then flood with water. This method has been tried, and will work; it is expensive, but can we better afford to have our most productive coal veins burn up? and is it not easier to extinguish now than in the future? These are questions of national importance, affecting not only the coal-mining companies, but the whole commonwealth.

CHAS. F. TORRANCE.

North Yamhill, Oregon.

BLASTING.*

By ARTHUR KIRK.

IN this age of improvement I know of no important industry in which so much hard labor and money are lost for want of intelligent study and use of modern improvements as in the simple operation of blasting.

When you bear in mind the fact that blasting of minerals lies at the very foundation of all that distinguishes civilized from barbarous life, you will at once admit that its importance makes it well worthy of our attention.

You are all aware that the houses of civilized men are very much superior to those of the barbarous races. The first point of difference is in the foundation, and almost the first things needed for the foundation of a house for civilized man are powder and blasting to get stone for the foundation.

Another point of superiority of civilized life is the abundance of manufactured iron and glass, yet I think that not one pound of all the immense quantities of these articles manufactured around Pittsburg is obtained without drilling and blasting to prepare either the coal, iron ore, limestone, or sand used in its manufacture. But the very nature of the work of quarrying seems to draw to it many men of one idea who work hard and think little; who having made holes in rocks for many years, insist, therefore, that they know all about blasting and persistently oppose all modern improvements.

Many farmers are living yet who have cut many harvests with a sickle before the days of cradles, mowing and reaping machines, etc. These might with the same propriety resist the use of mowing and reaping machines because they know all about farming.

Another reason why improvements are not introduced in blasting is because the owners of mines seldom give any personal attention to blasting, but leave it all to others, who seldom take any interest in improvements, and are often prejudiced against them and condemn them without a trial.

The subject of blasting may be divided into three divisions:

1st. The hole and how to make it.
2d. The explosive used.
3d. The manner of firing the charge.

1st. *The Hole and How to Make It.*—The common way of making the hole is by either churn or jumper hand-drills. Three men usually form a gang, and the gang make from eight to twelve lineal feet of hole per day in hard rock.

By either of these modes it is practically impossible to make a round hole—generally a three-cornered hole being made, which is very objectionable—because, if the hole is perfectly round it will present a uniform circular surface to the pressure, and retain the blast until its force is fully developed. But with a three-cornered hole the pressure on the long sides of the hole is concentrated at the corners, which, being required to resist more than their share of the pressure, give way and permit the explosive gases to escape before their force is fully developed, and only a large amount of smoke is produced.

A much better plan is to have the holes made by machinery; this secures a cheaper and better hole, being perfectly round, and thus retains the explosive gases until their power is perfectly developed, and do more execution on the rock and with less smoke. In close or underground work, where the air is bad, this is found to be of great advantage. With the latest improved steam drills a gang of three men often make from seventy-five to one hundred feet of hole in one day.

2d. *The Explosive Used.*—Explosives may be divided into chemical and mechanical combinations.

Chemical explosives embrace what are known as nitroglycerine, gun-cotton, dynamite, dualin, hercules, Ditmore powder, rendrock, mica powder, etc.

These are produced mainly by the combination of nitric acid, sulphuric acid, and fatty matter or glycerine, with cotton, tan bark, paper pulp, sawdust, soda, mica scales, pulverized charcoal, etc., as absorbents.

These will explode under water, which makes an excellent tamping. Most of them are unfit for sporting or military use; because their explosion is so instantaneous, it ruptures the gun before the ball can start. Their force is more like the blow of a large sledge, whose force is spent in an instant, while the explosion of black powder is more like the action of a powerful spring, which starts the projectile more slowly and continues to propel it until it escapes at the muzzle of the gun.

The manufacture of chemical explosives is of comparatively recent date, and in many cases is as yet imperfectly understood. Many alarming accidents have occurred in the handling of some of them, which has given a bad name to the whole family. But enough is now known about some of them to prove them to be perfectly safe when properly understood and handled, and very profitable in certain kinds of blasting.

Mechanically combined explosives are common black powder, carbo-azoteen, and mahoning powder.

These are composed mainly of saltpeter or nitrate of soda, sulphur, and charcoal, or tan bark.

All of these ingredients are first finely pulverized separately, and then mixed in certain proportions, and incorporated by being run under heavy wheels or rollers for from two to six hours, so as to mix uniformly and bring a certain proportion of each ingredient in immediate contact with the other ingredients.

The mass is then generally submitted to strong hydraulic or screw pressure, and then is called pressed cake. Then it is crushed by corrugated rollers and by means of sieves separated into the different sized grains of blasting, sporting, or military powder, each of which has its peculiar mark or name.

Carbo-azoteen is made by boiling these ingredients together, and has never been a success.

Mechanically combined explosives must be kept perfectly dry; even a slight degree of dampness injures them.

As a rule, the finer the grain the quicker the explosion and the smaller the charge; while for large blasts in rock, powder is now used to good advantage in grains as large as grains of corn, and in large artillery charges still larger grains are used, called pebble powder. We now come to the

3d. *Mode of Firing the Charge.*—Three modes are used—squib, fuse, and electricity. Squibs are made of about six inches of rye straw, filled with fine powder, and are used principally in coal blasting. The hole being drilled horizontally three to five feet into the coal, a charge of eight to twelve inches of F F blasting powder is generally put in, then an iron rod five-sixteenths of an inch in diameter, called a needle, is inserted in the hole back to the powder, then the hole is tamped full by having dry clay or clay pounded solid into it, and the needle is withdrawn, leaving an open passage like a pipe through the tamping to the powder. The squib is inserted in the mouth of this hole and a slow match applied to the outside end; the recoil of the powder burning in the straw throws the burning squib back along the needle hole or pipe to the powder chamber, and the explosion takes place. This mode of firing can only be used in horizontal holes.

Fuse consists of a thread of black powder incased in a wrapping of tarred hemp, and called hemp fuse—or in a wrapping of cotton, and called cotton fuse; then, to make it waterproof, a tarred tape is wrapped spirally around it, and then it is called single tape fuse, and will resist dampness a long time; or a double wrapping of tarred tape is wrapped around it, and called double tape fuse, which will burn and fire a charge of powder under twenty feet of water.

In all of these fuses there is a central cotton thread, which has been saturated with saltpeter, which makes it continue to burn when it would otherwise go out. Every precaution is taken to make the fuse continue to burn until the fire reaches the powder, and the explosion is produced. But, from some cause or another, holes sometimes hang fire, and are a source of great danger to the miner or quarryman. Holes thus charged, which ordinarily should explode in from one to three minutes, have been known to hang fire for twenty-four hours and then explode.

The third mode of firing is by electricity. When using it, the hole, the charge, and the tamping are the same as in firing with a fuse, but, instead of inserting the common fuse already described, an electric exploder is used, which is made thus:

A copper cap, one-quarter of an inch diameter and about one inch long, is filled one-third full of fulminate of mercury, into which is inserted the ends of two insulated copper wires connected by a small thread of platinum wire, and the end of the cap is then closed by means of melted sulphur, making it waterproof. Electric fuses are made four, six, ten, and fifteen feet long, with about two inches of the outer end stripped of the insulation and tinned.

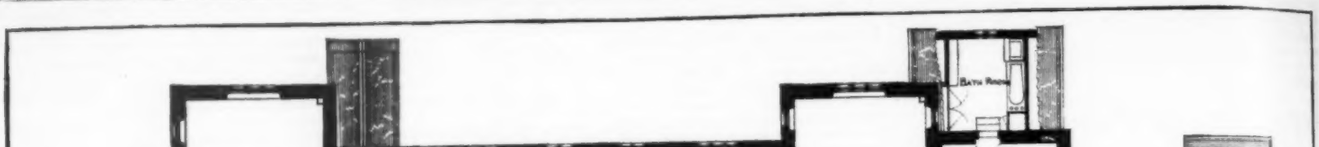
In using them the blaster selects an electric fuse long enough to reach the bottom of the hole and leave a few inches of wire out of the hole, then puts in enough powder to cover the bottom of the hole one-half inch deep, then his exploder, then one-fourth less powder than if fired with a fuse, and tamps the hole the same as with ordinary fuse; any number of holes may be thus prepared of equal or unequal depth or distances apart.

Directions for Firing.—One wire of the first hole is now connected to one wire of the second hole, and the remaining wire of the second to one wire of the third hole, and so on until all are connected; there will then be one wire of the last hole and one wire of the first hole left unconnected. These wires are then connected by means of long conducting wires to the battery at a place of safety, and, when everything is ready, the circuit is closed, and the small thread of platinum wire in the bottom of each hole becomes red hot, and each cap is exploded with great force at the same instant, and each hole assists its neighbor. And thus by simultaneous explosion, with only three-quarters of the powder used in ordinary fuse blasting, more than double the rock is moved with the same drilling.

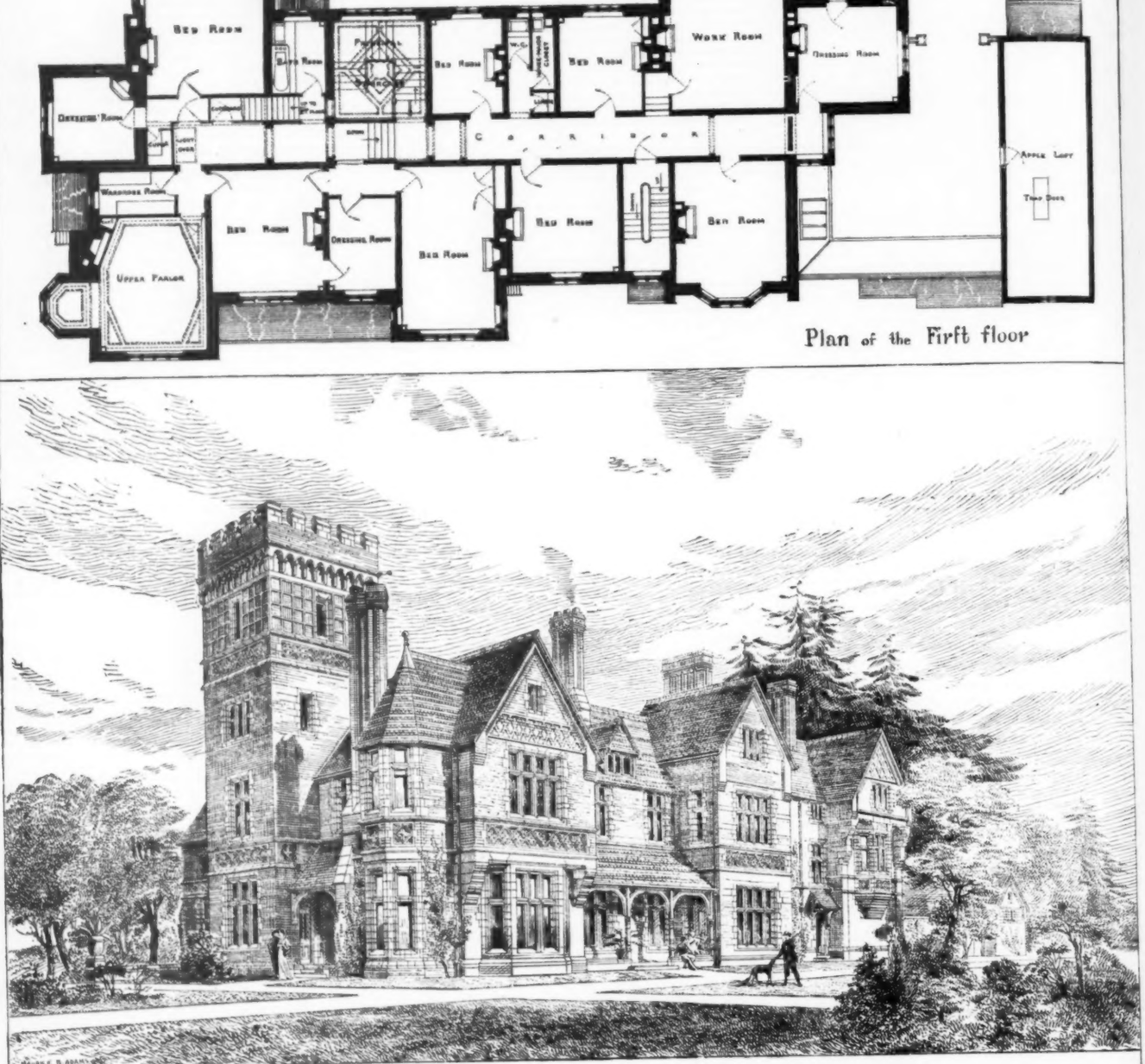
In quarries where fuse is used it is not uncommon to find six inches or a foot, or even two feet, of the bottom of the holes remaining unruptured after the blast has been fired and cleared away—the drilling of the unexploded piece of hole was so much hard labor lost, and the powder it contained was lost, for if the powder had done what was intended no part of the hole would have been left unexploded. No part of the hole is thus left unexploded where electricity is used, because in firing by electricity the first point ruptured is at the bottom of the hole, and the full force of all the explosive is spent in enlarging the rupture.

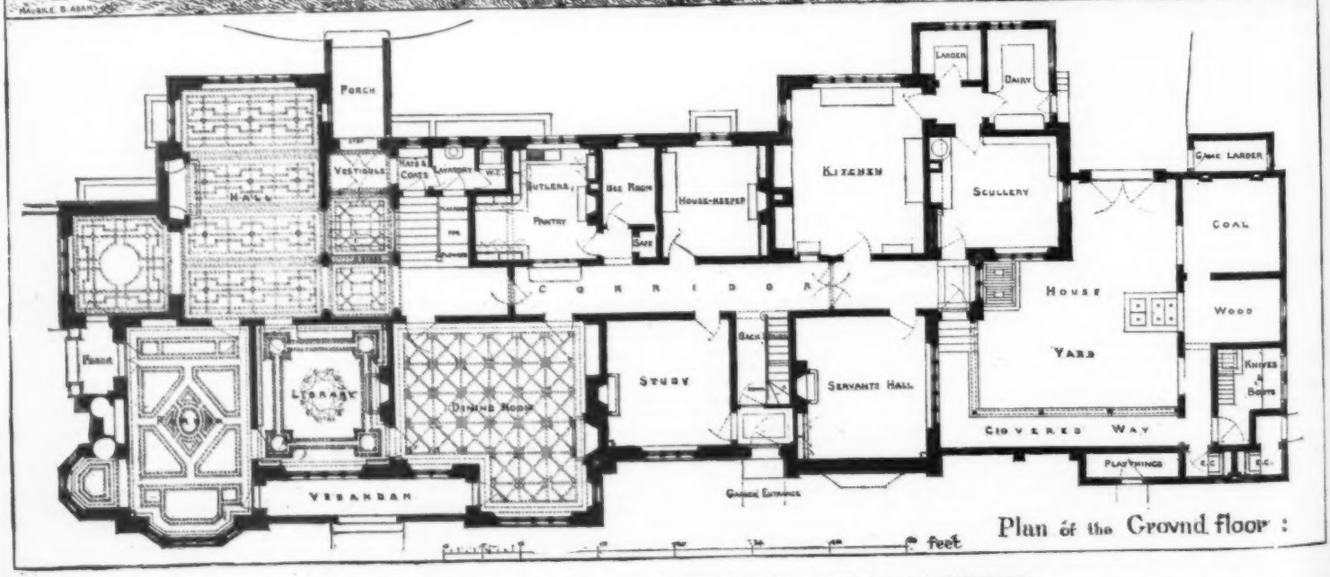
For profitable blasting by either mode of firing, the bottom of the hole in open work should be at least one-tenth less from the open front of the rock than the depth of the hole; thus, if the hole is ten feet deep, the bottom of the hole should not be more than nine feet from the face of the rock, and in some rock not more than eight feet, so as to make the bottom of the hole the weakest part of the blast. But if the hole is ten feet deep and filled up four feet with powder, and fired with a fuse at the top of the powder, there will only be six feet of rock on the top of the first point of rupture, and, there being nine feet in front of the hole, makes the top the weakest part, and the result is a great discharge of projectiles through the air, to the great danger of all around, and much of the material is lost; but if the same single hole had been fired by electricity at the bottom of the hole, the bottom rock would have been forced out, and the top rocks would tumble down and do no damage, and all be in place to be handled.

* Paper read before the Engineers' Society of Western Pennsylvania, October 19, 1880.



Plan of the Firft floor





Plan of the Ground floor :

ARTISTS' HOMES No. 10.—"YATTENDON," NEAR NEWBURY,

RESIDENCE OF MR. ALFRED WATERHOUSE, A.R.A., ARCHITECT.

The contrast between firing with a squib and by electricity is still greater, because a fuse may sometimes burn to the bottom of the hole before firing the blast, but a squib must always fire at the top of the powder, and as the needle hole is a full quarter inch in diameter, the first blast is a jet of orange flame from the needle hole, which is partly consumed powder, and cools into dense smoke, to the great annoyance of the miner; in light work, only the top is blown off the hole, the first point of rupture taking place at the top of the powder.

In conclusion, to show this is not idle theory, but actual fact, I may point to the shaft sunk this summer for the Chicago and Connellsville Coke Company, near Uniontown, under the superintendence of Mr. James Harrison.

Mr. Harrison has had great experience in everything connected with modern mining improvements, and on commencing work on the shaft procured the latest and best improved steam rock drill, an electro-magneto battery, and safe chemical explosives, and, with the assistance of Mr. Thomas, an experienced Welsh shaft-sinker, he broke ground about the 15th of last March, and two weeks ago he had sunk the shaft three hundred and twenty-five feet to the coal; has got his ovens and all his buildings up, and, I presume, is now making coke, which, under the old plan of sinking, he could not have done before next April.

I can also point to the shaft now being sunk by Mr. J. K. Taggart for E. K. Hyndman, near Connellsville, and to another near the same place, now being sunk by Mr. Hopkins for Mr. Wickham, of Connellsville, both of whom are using electricity and chemical explosives to good advantage.

I may further add that theoretically blasting by electricity has been known to engineers for thirty or forty years, for large blasts such as Hellgate. But it has only been within the last few years that the apparatus has been made so simple and portable as to be of any practical benefit in quarry work. It has now been so simple, and is so easily handled, that a youth can take the apparatus out of the tool box, lay down the cable to a safe place, charge five or six holes, tamp and fire them, and take up the cable and replace apparatus in tool box, all inside of ten minutes.

ARTISTS' HOMES.—No. 10.

WE give opposite illustrations of a house, at present in course of construction by Mr. A. Waterhouse, A.R.A., for his own residence. It is situated at Yattendon, a small village about ten miles to the west of Reading, in a district interesting alike from the beauty of its scenery and its historical associations. At the east end of the village there rises a hill of meadow-land, skirted by picturesque woods, on the summit of which, some 450 ft. above the sea level, stands a clump of tall and weather-beaten silver firs, which serve as a landmark for miles around. The house is placed under the shadow of these firs, and is approached through a wood, by a drive which leads to the open (oak) porch on its north side. The arrangements of the interior will be sufficiently explained by the plans of the chief floors, which we give herewith. The principal staircase, with a double arcaded screen at its head, is of oak; so are the fittings of the hall. The woodwork of the library, which is surrounded with shelves for books and drawings to the height of about 8 ft., is of American walnut; that of the dining room, of a combination of walnut, mahogany, and ebony. The woodwork of the parlor, and that of the "upper parlor" or boudoir, is painted; the rest of the house is of varnished pitch-pine. The fireplaces, some of which are commodious and furnished with seats, are of the simplest form, lined with glazed fireclay and tiles; the fires, either of coal or wood, being made on the hearth, without the use of any sort of grate. The external walls are hollow, bonded with Jennings's patent glazed terra-cotta tiles, and faced with red bricks of an excellent color, made on the spot, with a considerable admixture of buff terra-cotta. The roof is covered with red Ruabon tiles. The upper part of the tower on the west side of the house is occupied by a large cistern, intended for use in case of fire. From the lead flat above the cistern, an extent of view is obtained probably unequaled in this part of Berkshire. On the north stretch the Compton Downs. On the east one sees the valley of the Kennett, toward Reading, the town itself hidden by the hills dividing this river from the Thames, while beyond are two hills, southwest of Windsor. It is even reported among the villagers that the Royal Castle itself (distant twenty-five miles), could be seen before the growth of the woods obstructed the view. But it is on the south that the prospect is most varied and extensive. About a mile off rise the wooded slopes of Frilsham, with undulating corn-fields in the foreground. On the left, the land slopes to the little river Pang, where it flows through Stanford Dingley on its way to the Thames. On the right rises the dark ridge of Cold Ash Common and Grimsbury Castle, while beyond are the blue hills of Hampshire, above Kingsclere and Highclere, terminating abruptly at Walbury Beacon, nearly 1,000 ft. high. In making the excavations for the house, the remains of a beacon were brought to light. The interest of the sight was further increased by the discovery, about the same time, of a remarkable hoard of bronze implements, which were exhibited and described to a meeting of the Society of Antiquaries, by Mr. J. Evans, V.P., 5th Dec., 1878.—*Building News.*

AN INQUIRY INTO THE LAWS OF THE BEAUTIFUL IN MUSIC.*

By H. A. CLARKE, Professor of Music in the University of Pennsylvania.

THE laws of the beautiful in music are very difficult of ascertainment, owing to the total absence of any objective standard with which the results of this art may be compared. We judge of the poet by the power with which he presents what human experience recognizes as truth, or by the keenness with which he analyzes passions with which we are all familiar. The sculptor has the form of man and of animals as a standard with which to compare his work. The painter has the endless variety of nature to guide him. Hence these arts are imitative—not, in the strictest sense of the word, creative. But in the art of music none of these helps are to be found. Outside of ourselves music is non-existent. Nature, with all her endless variety of sounds—beautiful as many of them are—has no music, gives us no hint of any standard with which to test the creations of the musician. The songs of birds, the murmur of streams, and all the sounds of animate nature owe their beauty chiefly to circumstances and association, and are wanting in the first element of music.

We are, then, driven to the conclusion that music is a pure creation of man. Nature has taught him nothing. Other arts find their material and their motive ready and waiting for them. The beauty of nature would be the same had poet, sculptor, and painter never lived; but the beautiful in music had to be slowly and laboriously evolved by man himself. He must first select from the great mass of sounds those that will form a scale—an operation that took some five thousand years. He must devise laws for the combination of these sounds. He must patiently spend centuries in devising instruments for the production of these sounds, and must learn by ceaseless efforts to use these instruments. And even when all this is done the result may not be music, or may be bad music, which is the same thing. This brings us to the question: Why is *this* good music? Why is the other bad music? Are not both straitly conformed to the rules? Yes. Cannot both be equally well performed? Yes. Then what is the intangible something which makes such a vast gulf between them? We cannot, and never will be, able to say. For want of a better explanation we call it genius; but this only removes the question a step further. As I said before, man has had to make his own standards in this art, and the inevitable consequence of having no independent standard is, that the ideal of good music has varied and always will vary while humanity exists. The most we should say of any composition is that the majority of those *best* qualified have consented to its superiority. In short, no definition of good music can be given until we can trace with unfailing precision the connection between sound and emotion, or sense and sensation.

It is comparatively easy to account for the emotions excited by the sister arts. They appeal to universal experience. As an illustration, the pleasure of looking at a well painted landscape is chiefly made up of memory. We all have memories, more or less vague, of beautiful scenes of wood, or seashore, or mountain; these memories are appealed to by the painters, and our gratification is in proportion to the truthfulness, as we call it, of the appeal. We thus have at hand a means of checking our impressions by this hardly conscious reference to well known standards.

But what experience or analysis or memory will account for the emotion produced by a Beethoven symphony? What is it when reduced to its elements but a heterogeneous mass of sounds, of various pitch, quality, and intensity? All attempts at explanation have failed and must fail. One of the greatest of philosophers has tried to prove that the imitation of natural sounds is the origin of music—falling into the mistake so common to scientific men, of confounding *sound*, no matter how agreeable, with music; whereas, sounds bear the same relation to music that pigments do to painting.

But although we are unable to say what constitutes beauty in music, we are able to state with some confidence certain necessary conditions to which it must conform, or it could not be beautiful, still remembering that it may fulfill these conditions and yet resemble music only as an architectural drawing resembles a picture.

The first and the fundamental law of music is rhythm. Rhythm in sound means the same thing as symmetry in form. Symmetry, as defined by Ruskin, is the reproduction at equal spaces of the same figures and the same arrangement. Rhythm is the reproduction of an accent at equal intervals of time. It is strange that the flight of time should be one of the essential conditions of this the most evanescent of the arts. We are not without proofs that rhythm is the true genesis of music. The music of all savages and of the ancient civilizations was largely composed of pulsatile instruments, as the sistrum, crotalus, drum, cymbal, and so on. We have here the first quality that distinguishes music from natural sounds; no sound in nature, not even the songs of birds, is rhythmical. Philosophers have tried to explain this inherent love of rhythm and symmetry in the hypothesis that space and time are so vast that the human mind shrinks from any attempt at their comprehension as wholes, and feels the need of some recurring points of rest, without which it is lost in their vastness.

I must digress here for a moment to give my reasons for believing that music originated in the love for rhythm, not in the attempt to imitate natural sounds. Mere noise, when rhythmic, is a great exciter of the passions, particularly of the savage's master passion—the love of fighting. Hence all nations, savage and civilized, have used and still use drums, cymbals, gongs, etc., as a necessary part of their war material. It is a common custom with savages when sitting round their camp fires or at their solemn "pow-wows" to recite the deeds of their warriors or ancestors, the recitation being accompanied by the beating of drums in regular rhythm. This recitation would soon accommodate itself to the drum beat and would develop into a rude chant. The voice would naturally rise when describing how the hero slew his foes and would fall when lamenting his death. The repetition of the same story, with the same inflections of the voice, would give rise to a rude melody. It would seem that the ancient Greek music arose in this way, because it was lacking, as far as can be known, in *musical* rhythm, *i. e.*, the rhythm depended on the poetry, the musical sounds having no definite value. We have here the practice of recitation to musical sounds carried to its highest development. They, the Greeks, neglected the rhythmic accompaniment and bestowed all their attention on the reciting chant. It is to them we are indebted for all the forms of chant we now possess, viz., the Gregorian or Ambrosian and Anglican. It is strange that with their keen artistic sense they should have taken the wrong direction in this art and never made the discovery that rhythm in the *music*, not the *poetry*, was the true path to the highest development of the musical art.

But although cultivated music took this direction, the "folk-music," *i. e.*, dances and songs, were all of necessity conformed to rhythm, and it is to them that our modern music must trace its origin. The feeling for the combination of melody with rhythm gradually displaced the chant forms, and in the thirteenth or fourteenth century first claimed the attention of cultivated musicians, and has since gradually, but surely, displaced the older form, which is now only retained in civilized countries in a modified form for religious purposes. In short, a close study of the history of music seems to indicate that it began with rhythmic noise produced by drums or even by striking two sticks together; to this was added recitation; this developed into the chant, consequently vocal music, as we know, was first developed. But, the universal practice of dancing also required some rhythmic accompaniment. This the drums, triangles, etc., would also supply, still united with voices, which would be compelled to measure their lines or sentences in such way as not to interfere with the rhythmic movement of the dancers; as instruments improved the use of voices for this purpose would gradually disappear, and from this has grown measured instrumental music. In proof of this all the compositions for instruments, with few exceptions, until the close of the eighteenth century, were collections under the name of "suites" of dances, such as gavottes, gigues, sarabandes, etc. So the savage had rhythm without music, the ancients music without rhythm. It was left for the moderns to combine the two and develop all the resources of the art.

The next law—one degree higher—is melody. This is dependent on the first law, and consists of sounds of different pitch adapted to some predetermined rhythm. Melody is one remove farther from natural sounds. It presupposes a definite arrangement of sounds called a scale, a thing that does not exist in nature, as every one knows who has tried to write down the songs of birds, all of which are constructed of intervals that do not exist in our scales.

The third and a still higher law, but still dependent on the two previous, is harmony, or the art of combining sounds. Melody and harmony are to each other as drawing is to painting. Drawing may exist without painting, but not painting without drawing—or, at least, it is very poor painting. So melody may exist without harmony, but harmony without melody makes very poor music, if it deserves the name at all.

Again, a skillful drawing will, as painters say, suggest the color, and give an exact representation of the object; but the completed painting, with its gradations of light and shadow, its blending and contrasting of tints, seems to bring nature herself before us. So a beautiful melody heard alone will give suggestions and hints of its capabilities of expression; but with the composer's harmony it brings before us his whole thought, with every shade of expression enhanced by the tints of the harmony. We are now far beyond nature, which has no hint or suggestion of musical harmony. It is man's own kingdom. He created it after centuries of work, and has possessed it for little more than two centuries. The fourth and highest law in music is form. As we advance, the mystery that surrounds the art deepens instead of clearing up. Who can say by what process of reason or instinct we have arrived at what we recognize as the highest form in music—the sonata? Why have we decided that the theme that is suitable for sonata treatment will not do for rondo treatment, and the reverse? Or, why is the sonata a higher, nobler form than the rondo? Form is an extension or development of rhythm. We have first the rhythm of the bar, then of the phrase, then of the theme, and lastly of the alternation and recurrence of the various themes. It might be compared to the revolution of satellites round their planets, of planets round their suns, and of suns round their unknown, unsearchable center—*the ideal* of the composer.

I have now stated all that is definitely ascertainable concerning the laws of the being of this art. It seems very little; but when we remember that it is the unaided creation of man, we have a truer appreciation of the difficulties that he has had to overcome since he first attempted by rude drums and cymbals to divide time rhythmically, or by pipes and strings to make weak attempts at melody, or by barbarous successions of fourths and fifths essayed to combine sounds into harmony. From these rude beginnings has grown this most perfect of the arts. And it would seem in our day that its forms and means of expression have been all elaborated to their greatest possible perfection, and that no advance can be made until a *new* scale and a *new* harmony—of which we cannot even conceive or see any indications—be evolved.—*Jour. Franklin Institute.*

PYROGALLOL FOR DRY-PLATE DEVELOPMENT.*

PYROGALLOL, or pyrogallic acid, is made, as the latter name implies, by heating gallic acid; but the process, as usually conducted, is very uneconomical, on account of the difficulty of preventing the decomposition of the pyrogallol into metagallic acid. According to the equation,

$$\underset{\text{Gallic acid}}{C_7H_6O_5} = \underset{\text{Pyrogallol}}{C_6H_6O_3} + \underset{\text{Carbon dioxide}}{CO_2}$$

gallic acid should yield eighty per cent. of its weight of pyrogallol, but the amount usually obtained is very much less than this; on the average not more than thirty per cent. is formed. The greatest yield is given at a temperature of from 185° to 200° C. If the heat be allowed to rise to 250° the gallic acid is converted into metagallic acid, carbonic dioxide, and water, thus:

$$\underset{\text{Gallic acid}}{C_7H_6O_5} = \underset{\text{Metagallic acid}}{C_7H_4O_4} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water.}}{H_2O}$$

The difficulties attending the conversion of gallic acid into pyrogallol have their natural effect on the price of the latter article. Photographers may be interested, therefore, in knowing how they may be able to prepare their own pyrogallol from gallic acid by a very simple and sufficiently expeditious process.

Ten grammes (say 150 grains) of dry gallic acid, and 30 c.c. (say one fluid ounce) of glycerine (preferably Price's), are placed in a two-ounce flask or wide test tube and heated on a sand tray to a temperature of from 190° to 200°, so long as bubbles of carbon dioxide are seen to be formed in the liquid. The gallic acid readily dissolves, and in a very short time it is entirely converted into the theoretical quantity of pyrogallol; this fact has been verified by direct observations made in my laboratory. The brown, viscous liquid, after cooling, is diluted with 1,000 c.c. (say 34 ounces) of water. A solution is thus obtained, each half ounce of which contains rather more than one and a half grain of pyrogallol, sufficient, therefore, for developing a quarter plate, according to Mr. Swan's instructions. In containing glycerine, it of course resembles Mr. B. J. Edward's solution, which has found favor with many photographers.

I have developed a number of plates (mostly Swan's) with solutions of pyrogallol prepared in this way, with results in no wise different from those obtained by the use of a pure aqueous solution of crystallized pyrogallol of equal strength. The method of conversion is very easy; the only point to be attended to is the temperature, which should not be allowed to exceed 200°, otherwise the glycerine becomes very brown in color. The thermometer should be supported in the flask or tube by a cork, perforated, of course, to allow of the escape of the carbon dioxide, and the bulb should be surrounded by the liquid, which should be shaken from time to time. The solution may, however, be very dark-colored without sensibly staining the film, provided, of course, that the time of development be not unduly prolonged—a remark which applies equally to the ordinary method of developing by means of the crystallized acid.

As the present price of pyrogallol is about seven times that of gallic acid, the above process may be worthy of the attention of photographers who practice alkaline development.—*T. E. Thorpe, F.R.S.*

* Paper read before the Utopian Society, with additions, December, 1880.

* A communication to the Photographic Society of Great Britain.

PHOTOGRAPHIC TRANSPARENCY.

AT a recent meeting of the Photographic Society of Ireland, Professor Hartley read a paper on "Photographic Transparency, or the Application of Photography to Chemical Research," and defined photographic transparency as the power which colorless substances possess in different degrees of transmitting the ultra-violet or photographic rays. During the last eight years he had been engaged in researches on this subject, the foundation of which was laid by Professor Stokes, of Cambridge, and the late Dr. W. A. Miller, of King's College, London. The researches of the latter were made by the aid of photography, but Professor Stokes used fluorescent screens for investigating those almost invisible rays. The method of photographing spectra with quartz lenses and prisms in such a way that the least refrangible and most refrangible rays were in focus at the same time was next described, and the sources of the ultra-violet rays were stated to be a succession of electric sparks obtained by means of an induction coil and Leyden jar, the sparks passing between electrodes of nickel wire containing a trace of copper. Small vessels with sides composed of plates of quartz were exhibited, which were used for holding the liquids under examination, and an instrument which was a combination of spectroscope and photographic camera was shown. Photographs were handed round of the spectra of various metals, including aluminum, iron, nickel, and cadmium. It was stated that the substances—quartz, Iceland spar, and water—were practically diactinic, that is to say, photographically transparent. A diagram exhibited the fact that the ultra-violet or invisible photographic rays constitute a spectrum at least five times as long as the visible or colored spectrum, but the purest optical glass, made by Fiel, of Paris, cut off nearly all this ultra-violet portion. A sketch of the investigation as originally planned was then given, and the results of the examination of a large number of organic substances made in conjunction with Prof. Huntington was then stated in detail. Examples showing the extraordinary delicacy of the method in the detection of minute traces of impurities in organic substances were mentioned. The supposed constitution of various series of organic substances was then stated. The peculiarities of the linking together of the carbon atoms in alcohols and fatty acids, essential oils, benzine and its derivatives, naphthaline and anthracine, are capable of being recognized by the degree and character of the photographic transparency of these compounds. The degree of dilution which some of the substances named will withstand before they become capable of perfectly transmitting the ultra-violet rays is extraordinary; for instance, in the case of benzine the substance may be mixed with 2,500 times its weight of alcohol; naphthaline with more than 400,000 times; and anthracine with 50,000,000 parts of alcohol. Photographs showing the bands of absorbed rays characteristic of this latter substance were exhibited and compared with a photograph of the alcohol used in the experiments. These researches promise to throw light on the constitution of many carbon compounds. Prof. Hartley stated that difficulties were encountered which proved almost insurmountable when the wet collodion process was at first employed, and that the success of the work was largely owing to the fact that gelatine plates, which could be bought in large quantity, and kept almost any length of time, were admirably adapted for the purpose.

HOW TO MAKE SKELETON LEAVES AND CRYSTALLIZED GRASSES.

THESE pleasing preparations for household adornment may be made as follows: There is a slow and quick method; the former is by procuring the natural decomposition of the pulpy substance of the leaf by exposure to light in a dish of water, the quick method is by the use of a weak alkaline destructive solution, of which soda and lime are the active agents. By the slow method one may proceed as follows: The leaves are laid out smoothly in a pan or dish, and covered with rain water two or three inches deep, and are held down by means of sheets of glass resting on small stones at the corners by which they are prevented from pressing too closely on the leaves. They are exposed to the sunlight in a warm window. In two or three weeks they are examined, and all those that have become soft and pulpy are removed to another dish to be cleaned. The rest are left until they, too, become soft. The softened leaves are carefully removed one by one by being floated on to a small sheet of glass; the pulp is pressed out by means of a small stiff painter's brush or a tooth brush, used by tapping up and down and not by a sweeping motion. This breaks up the pulp only, which is washed away by pouring water upon it from a small pitcher. To make this convenient, the glass may be placed on two wooden bars resting on the edges of a deep dish with a towel under it to catch the splashings.

The quick method is as follows: Four ounces of sal-soda are dissolved in a quart of hot water, two ounces of quicklime are added, and the whole boiled for twenty minutes. The solution is cooled and strained. The leaves are then boiled in this for one hour, or until the pulp is easily removed, when it is washed off as already mentioned. The fibers remain, leaving a perfect skeleton or framework of the leaf. This is bleached by exposure to a solution of one tablespoonful of chloride of lime in a quart of water, strained clear from sediment. The skeletons are placed in a dish, covered with this solution and kept in a dark closet for two days, watching in the meantime that the fibers are not softened too much and thus injured. After bleaching, the leaves are steeped in clear soft water for a day, and then floated off upon a card and placed between soft napkins until dry. They are then ready to be finally pressed, bent, curled, or arranged in bouquets or groups.

Crystallized grasses and sprays are made as follows: The bunches are first arranged in a suitable manner, tied and secured; a solution of four ounces of alum to a quart of boiling water is made, and when this has cooled to about 90° or blood heat, the bunch of grass and leaves is suspended in it, in a deep jar, from a rod placed across the mouth of it; as the liquid cools crystals of alum are deposited upon every spray, the finer and smaller the weaker the solution is made. This deposit of crystals occurs in the cooling liquid, because hot water dissolves more alum than cold water, and as the water cools the excess of alum forms crystals which attach themselves to any fibrous matter in contact with it more readily than to anything else. These crystals enlarge by accretion constantly, as long as there is an excess of alum in the solution. When the supply is exhausted the solution is warmed and more alum is dissolved in it; it is returned to the jar and the bunch of grasses is replaced. When sufficiently covered with crystals it is taken out and dried and is finished.—*N. Y. Times.*

THE ELECTRICAL PHOTOMETER.

PROF. STEBBING gives in the *British Journal of Photography* an account of a recent meeting of the Photographic Society of France, when M. Léon Vidal made a communication and experiment on his selenium photometer. He began as follows:

All photometers which have been employed up to the present time in photography are based upon a chemical action produced by luminous rays upon divers substances sensible to light. Light acting upon these substances during a certain time, the result is that a decomposition or a combination takes place, by which a measurement more or less exact can be taken of the intensity of the chemical force of the light at the moment or during the observation. In this case there is an accumulation of successive and repeated actions of the luminous rays, and not of one immediate effect. The effect is continually changing as regards the power of light. No instrument up to the present time has realized the desideratum to make observations on the continual changes in the power of light, in the same manner as the physical changes are observed by the thermometer and barometer.

The phosphorescent photometer, by Mr. L. Warnerke, receives a purely physical action, but it cannot give repeated and continual observations. The phosphorescent substance must be exposed to the action of light, and then the instrument must remain inert during the examination in order to seek the degree of light.

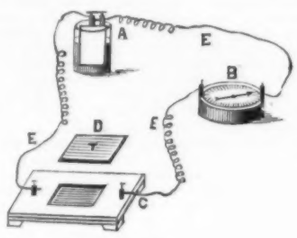


FIG. 1.

A, Galvanic battery. B, Galvanometer. C, Selenium receptor. D, Cover in order to intercept the light at will. E, E, E, Connecting wires.

M. Vidal, after having become acquainted with the remarkable experiments of Mr. Graham Bell on the photophone, imagined that he could turn the discoveries of that gentleman to account, and by so doing mark a progress in photographic art, to which he has dedicated his talents, his energies, and, in fact, his life. He came to the conclusion that an instrument might be made which could give permanent readings, purely physical, not showing the chemical force of light, but the illuminating power of rays, and giving in a permanent manner all the degrees of light, let the variations be ever so rapid in the intensity of the illuminating power of the light to be studied.

The experiments of Werner, Siemens, Adam, and other *savants* who studied the properties of selenium (he said) confirmed his faith in the possibility of such an instrument, and, above all, the remarkable power of this metalloid, after having been heated under certain conditions, to become a better conductor of an electrical current when under the influence of a ray of light either natural or artificial.

Graham Bell's selenium receptor was first experimented upon by M. Vidal. He also employed whatever source of electricity he could obtain for his first experiments, as well as the simplest form of galvanometer he could lay his hands upon, and determined, as soon as he could see a chance of success, to study each of those instruments (all of which are completely necessary for the formation of a photometer such as M. Vidal dreamt of) one by one, and make all the improvements necessary for their better working. What electricity

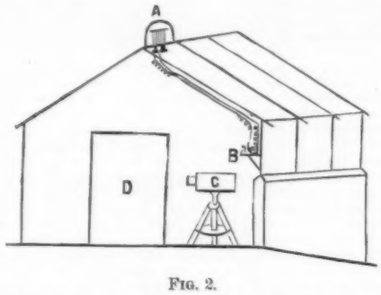


FIG. 2.

A, Selenium instrument or receptor in the form of a cylinder covered by a glass dome. B, Galvanometer placed as near as possible to the operator. C, Camera obscura. D, Background.

is the best? What galvanometer is to be preferred? What shape and form should the selenium receptor have in order to obtain the maximum of effect? These are the questions which M. Vidal determined to solve, and, having done so, has come to the following conclusions:

1. That a very feeble current suffices; a single element and a regulator are all that are necessary. The chief requirement is to have a regular and constant current, which (he says) is very easy to obtain with a current of only feeble intensity.

2. As to the galvanometer, he is of opinion that observations to be made in the laboratory or at home are more reliable when an astatic galvanometer is employed. A magnet must naturally be employed to bring the needle to 0. For observations in the country, on a photographic excursion, an ordinary compass galvanometer and a single dry element is as good as anything. Evidently the oscillations of the needle are less marked, and, therefore, not so easy to be read; but with a little practice, and, above all, in using a magnet, by bringing back the needle to 0 the deviation can be easily seen and noted.

3. A cylindrical form appears to M. Vidal to be the best for the selenium receptor; nevertheless, a flat form can be employed when experimenting with artificial light.

I have had the pleasure of following the experiments of M. Vidal in his own home, and was charmed and delighted at the results he obtained I look forward to the future with confidence that photography will be endowed, ere long, with an instrument by which the time of exposure can be seen at any moment of the day by simply looking at the deviation of a magnetic needle.

I will now endeavor to give a diagram, in order to show the readers of the *British Journal of Photography* the instrument at present employed by M. Vidal, in which instrument I am the more interested because I believe it to be the greatest discovery in photographic appliances, and the more pleased that the honor will fall upon a gentleman who has done so much for photographic knowledge, and one, moreover, I have the honor and pleasure of classing as one of my truest continental friends.

The instrument, as aforesaid, is composed of three principal elements: A, the source of electricity; B, the galvanometer by which the passage of the electric current is ascertained; and C, the box holding the selenium. To set the apparatus at work, the cover D is lifted off the selenium receptor. Light falling upon this instrument facilitates, according to its brilliancy or power, the passage of the electric current, or, in other words, renders it more or less a conductor of electricity. When the sun shone fully upon it the needle of the galvanometer marked five; as soon as a cloud obscured the orb of light the current was obstructed, and immediately the needle receded one or two degrees. M. Vidal informed me that, although in continual use during the last month, he could not perceive that the receptor had modified or become "fatigued," of which Siemens and others have spoken. On this point M. Vidal will not pronounce a verdict until he has devoted more time to these interesting experiments.

I cannot follow M. Vidal through all his experiments on the action of different-colored lights; suffice it to say that the different-colored glasses placed over and above the receptor make no greater change than an ordinary pane of white glass. Heat produces no visible change.

The great value of this instrument consists in the immense service it will render to our observatories and meteorological establishments in having an apparatus indicating every change that takes place in the illuminating power of the rays of light. To the photographic profession what an admirable auxiliary has come to our aid to enlighten us as to the exposure required at any time of the day for a plate of known rapidity! The galvanometer is placed in the interior of the studio, and the selenium receptor on the roof of the glass house, only protected from the inclemency of the weather and atmospheric changes by covering it with a glass dome (see Fig. 2). The operator has only to cast a glance at the needle of the galvanometer in order to judge correctly the time required for the exposure. The instrument will be seen to be continually oscillating backward and forward by the change in the light, the same as the thermometer is always rising and falling by a change in the heat of our rooms, as the barometer depends upon atmospheric pressure.

M. Vidal is not satisfied with the excellent results as yet attained; he desires to complete the instrument in such a way that the exposure shall be self-acting, in the following manner: Supposing twelve seconds are required to produce a negative in the camera: the object he desires to attain is that as soon as the twelve seconds of light are accomplished a mechanical contrivance shall close the lens. Now, I speak of twelve seconds of light. I wish to be understood that I mean standard light—a light which has been previously measured; not twelve seconds by a chronometer. To make this more clear: supposing twelve seconds are being counted, a black cloud darkens the face of the sun, the operator is at a loss what to do; he exposes at random fifteen or twenty-five, but it is impossible to give a true judgment, whereas the dream of M. Vidal is to render this mechanically and mathematically correct. How is this to be done? I imagine that in the circuit of the electrical current he will interpose a vibrating machine, such as an electric bell, the hammer of which must give so many vibrations per second. Now, if the light remain equal, the vibration will be isochronous; but should a cloud come on, the current will be partially stopped, and, therefore, it will take more than twelve seconds of time to complete twelve seconds of light. As to closing the lens automatically, I imagine that the vibrating bar is in communication with clockwork, and that it causes a cogged wheel to make one revolution in a minute of light. The wheel itself is divided by sixty pinholes, representing seconds. Supposing five seconds of light be required, the operator fixes a pin in the fifth hole, and as soon as contact is made, an electrical current closes the obturator. I am so interested and so charmed with this invention, that I am led away into the field of supposition; and I beg M. Vidal's pardon if I have forestalled him in explaining any of his ideas. E. STEBBING, Prof.

N. B.—Should any readers of the *British Journal of Photography* wish to construct a selenium receptor, this is how it is manufactured: A number of thin slips of *brass* about three inches long and three-eighths wide are laid side by side; between each a slip of mica is placed, only the mica is not quite so high as the brass. All these are held together in a brass frame and heated very hot. A selenium bar is now rubbed over the surface. As it runs like wax, it fills up all the holes left by the mica.—E. S.

THE PHOTOPHONE.

THE highly interesting and important researches of Professor Graham Bell and Mr. Sumner Tainter, which have resulted in an altogether new branch of philosophical inquiry—photophonic science—have suddenly extended the physical importance of the substance selenium, indicating as they do practical, and probably very important applications of the discovery made in the year 1866, and announced by Mr. Willoughby Smith to the Society of Telegraph Engineers in the beginning of 1873, that the electrical resistance of the substance selenium alters under variations in the illumination to which that body is exposed. This remarkable discovery induced several eminent investigators to take up the subject, and a large number of very valuable published researches was the result. Upon the aggregate results of these researches is based the knowledge of the apparently anomalous property of selenium, which was turned to account by Professor Bell and Mr. Sumner Tainter in the receiving instrument of the photophone; and as that instrument, and the very interesting researches which led up to it, have very deservedly excited a large amount of public attention, it may be of interest to many of our readers to take a rapid survey of the labors of previous investigators (all of whom were alluded to by name in Professor Bell's first announcement of his discovery), for the antecedents of the photophone are as important in the world of science as the perfection of that instrument itself.

Before referring, however, to the discovery first announced by Mr. Willoughby Smith of the influence of light

upon selenium, we will say a few words about that substance, which occupies a sort of neutral position between the metallic and the non-metallic elements, partaking more or less of the characteristics of both. Selenium (symbol Se, atomic weight 79·4) is a reddish black solid body, slightly transparent, and possessing an imperfect metallic luster, which is destroyed by crystallization when slowly cooled after fusion; it melts at a temperature a little above boiling water, and when slowly cooled is completely changed in its physical character, becoming of a lead gray color, perfectly opaque, and, moreover, a conductor of electricity, which in its normal or vitreous state it is not. It is insoluble in water and in alcohol, but it dissolves in bisulphide of carbon, and crystallizes from a solution in that body.

Selenium was discovered by Berzelius in the year 1817, in his attempt to discover, in the residual deposit produced in the distillation of iron pyrites (a part of the Nordhausen process for the manufacture of sulphuric acid), a new source of supply of the rare metalloid tellurium; and this discovery of selenium forms an instance, of which there are many in the history of science, of a great success resulting from a scientific failure.

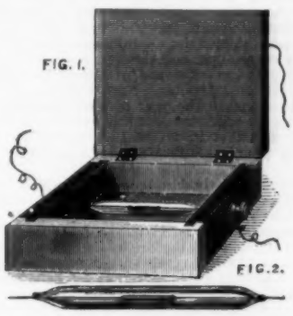
Selenium, which resembles both sulphur and tellurium in its chemical relations, is, in its vitreous condition, singularly like sealing wax in appearance and in some other respects. It fuses at about the same temperature, becoming viscous. Like sealing wax, it is in its vitreous condition a non-conductor of electricity, but it becomes a slight conductor when fused, and if allowed to cool very slowly it crystallizes, retaining its electrical conductivity, and having all the appearance of a metal. In this condition, owing to its high electrical resistance, it has been employed with a certain amount of success for high resistances, in the place of coils in submarine telegraphy and for other electrical purposes. In this way it was successfully employed by Mr. Willoughby Smith in the laying of the 1866 Atlantic cable, and it was also employed by him in the laying of the 1873 and 1874 cables; also in the Lisbon and Madeira, Madeira and St. Vincent, and St. Vincent and Pernambuco lines, as well as in the Australia and New Zealand submarine cables.

While making the experiments prior to its introduction for the purpose above alluded to, it was observed by Mr. May—who was at that time Mr. Willoughby Smith's assistant at the works of the Telegraph Construction and Maintenance Company—that when the selenium resistance bar was exposed to the light, its electrical resistance was considerably reduced; and in consequence of Mr. May's discovery, Mr. Willoughby Smith instituted a series of most interesting and valuable researches, the results of which he brought before the Society of Telegraph Engineers. Mr. Willoughby Smith employed in these researches small bars of selenium from 1 to 1½ millimeters in diameter, and from 50 to 60 millimeters long. Each was hermetically sealed in a glass tube, as shown in Fig. 1, a platinum wire being fixed into each end of the bar of selenium and passing through the sealed up ends of the tube. The tubes so formed were fixed in a box, with insulating ebonite ends, as shown in Fig. 2, having a flap cover which could be quickly opened and closed by means of a cord, and attached to the ebonite ends were terminal screws by which the selenium resistance bar could be placed in circuit with a battery and galvanometer. Fig. 3 is a diagram of the connections of one of the experiments made during the laying of the 1866 Atlantic cable. At the end of the cable, the conducting core of which is represented by the straight line, C C, was placed a selenium bar, S, and a galvanometer, G, and these were placed in circuit with one another and with the core, C C, and iron sheathing, A A, respectively of the cable. At the other end of the cable was a battery, B, of 100 cells, its poles being connected respectively to the core and sheathing of the cable. Thus a selenium bar and galvanometer were connected to the battery by the cable conductor, and the iron outer sheathing of the cable constituted an earth or return circuit. The following table, which explains itself, gives the results of the last-named experiments:

Time.	Selenium closed in Box, Gas in Room not Burning.	Cover off Box, Gas not Burning.	Cover off Box. Two ordinary Gas Burners alight in Room.
Min.	Resist. in Megohms.	Resist. in Megohms.	Resist. in Megohms.
1	1483	1419	1047
2	1483	1405	1018
3	1483	1405	1018

This was among Mr. Willoughby Smith's earliest experiments, but since that time he has entered into a long investigation of the subject, the results of which investigation he brought before the Society of Telegraph Engineers in November, 1877.* This investigation was very carefully conducted, and embraced an exhaustive series of experiments made with seventeen samples of selenium. The selenium bars were of different sizes, varying from about $\frac{1}{4}$ in. to $\frac{3}{4}$ in. in diameter, and from about 1 in. to 2½ in. in length. These seventeen bars were fixed in a box with ebonite ends, and having as many pairs of binding screws on the outside, communicating respectively with the selenium bars inside. The temperature of the interior of the box was accurately noted by observation of a standard thermometer, the bulb of which was placed in the center of the box, and the scale projecting through one of the sides, and the reading of this instrument was checked by measuring the resistance of a great length of fine silk-covered copper wire, which was distributed over the bottom of the box, its length being adjusted so as to offer a resistance of 100 ohms when the thermometer stood at 63° Fahr. The resistance of each of the bars was ascertained by observing the deflection of a galvanometer connected with it under the influence of a current of constant electromotive force, and after substituting for the selenium bar under trial a known resistance, the deflection was again noted, and from the data thus obtained the resistance of the bar was determined. The rest of the apparatus consisted of an astatic reflecting galvanometer, the resistance of whose coils was 6,200 ohms, a Menotti battery of 100 cells, the internal resistance of each being 20 ohms, and a contact key. We have referred in detail to the arrangements adopted in Mr. Willoughby Smith's early experiments because they form an important and interesting link in the history of the subject. In all cases, with but one very doubtful exception, the resistance of the bars was diminished by an exposure to light, and Mr. Willoughby Smith found that the lower the intensity of the light the slower is its effect. During this research Mr. Willoughby Smith made a large number of experiments for determining the effects of variations of temperature on the resistance of the selenium bars, testing them first when maintained at a temperature of 100° Fahr., and afterward at a temperature of between 44° and 46°. From these experiments it was found that light has a much greater effect on the resistance of selenium at low temperatures than at high.

Experiments were then made to ascertain the effects on the resistance of selenium of light from different sources, and Mr. Willoughby Smith found what has been abundantly confirmed since, that solar light has more influence on selenium than any artificial light, not even excluding the electric light; and that even the daylight of a dull cloudy day produced a greater effect than the apparently brighter light from coal gas. During the progress of these experiments an interesting phenomenon was observed which indicates the extraordinary sensitiveness of crystalline selenium to minute vibrations in the intensity of radiant energy, which for the present purpose it is convenient to call "light." On an overcast day, when the daylight was so diffused that no true shadows could be cast on the box containing the selenium



bars, by objects a few feet distant, it was observed that whenever one of the assistants intercepted the light by passing in front of the box, the galvanometer deflection varied, although no sign of a shadow could be detected by ordinary observation. "Thus," as Mr. Willoughby Smith says in his paper, "the shadow of a man, although not visible to the naked eye, was found to interfere with the mechanical laws which govern the motion of ordinary matter." From a highly interesting series of experiments with selenium bars exposed to the varying light of the moon during a lunar eclipse, Mr. Willoughby Smith came to the conclusion that while selenium is under the influence of light, the time of exposure is an element affecting the result, and that its electrical properties are temporarily altered, the selenium but slowly returning to its normal resistance when the light is removed. In this respect the action of light bears a very close resemblance to the polarization of a dielectric, such as gutta percha under the influence of an electric charge, for after the removal of the cause of polarization, gutta percha gradually becomes depolarized, and returns to its normal

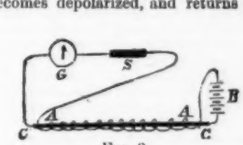


FIG. 3.

condition. Want of space does not permit us to do justice to Mr. Willoughby Smith's most interesting researches, but we have no hesitation in saying that they struck the key note of all the subsequent researches of other investigators upon the electrical properties of selenium, and formed the point of departure to a path which, branching with that appropriated to telephonic science, led directly to the latest marvel of science, the photophone and its subsequent results. To Mr. Willoughby Smith must also be accorded the merit of having made the first photophone, or at all events of having made the first recorded experiment in the science of photophony, for at the meeting of the Society of Telegraph Engineers, which was held on the 23d of May, 1878, Mr. Willoughby Smith—speaking in the discussion on Mr. Preece's paper on the microphone—described an experiment in which he had heard a beam of light fall upon a bar of selenium. Taken in connection with Professor Bell's splendid researches, this statement of Mr. Willoughby Smith is so significant that we will give it in his own words. "Mr. Preece," he said, "has told us that by the aid of the microphone the tramp of a fly can be heard, resembling that of a

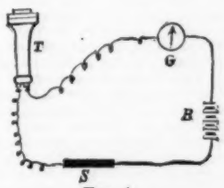


FIG. 4.

horse walking over a wooden bridge; but I can tell you something which to my mind is still more wonderful, that by the aid of the telephone, *I have heard a ray of light fall on a bar of metal.*" . . . If a bar of selenium, excluded from the light, form part of a circuit in which are included a battery, a telephone, and a galvanometer, nothing will be heard until the light be allowed to fall on the selenium, which is done simply by raising the lid of the box in which the selenium is placed, when immediately sound is heard in the telephone, and the needle of the galvanometer moves, simply because the resistance of the circuit is reduced, and, consequently, the electromotive force increased." The arrangement described in the above quotation is shown in the diagram, Fig. 4, in which T represents a telephone in circuit, with a battery, B, a galvanometer, G, and a selenium resistance bar, S.

Immediately after Mr. Willoughby Smith's first announcement of the action of light on selenium, the subject was taken up by several investigators, and about seven weeks after that announcement a short but highly interesting paper was read before the Royal Society by Lieutenant Sale, R.E., in which the author described a series of experiments upon the electrical behavior of a selenium bar, when exposed successively to the various colored rays of the solar and electric spectra,* and from which he arrived at the conclusion, not only that the resistance of selenium is largely affected by light, but that this effect is not produced by the actinic rays, but is at a maximum at or just outside the region of the red rays, at a place nearly coincident with the locus of the maximum of the heat rays. Lieutenant Sale also convinced himself that the effect of varying the resistance is certainly not due to any change of temperature in the selenium bar, and showed that the electrical effect of light upon the resistance of selenium is instantaneous, but that, on cutting off the light, the return to the normal resistance is not so rapid. From these results, Lieutenant Sale came to the conclusion that there exists a power in rays, nearly coincident with the heat rays of high intensity, of altering instantaneously, and without change of temperature, the molecular condition of the substance selenium; and this opinion, which was published nearly eight years ago, derives additional interest from the controversy, which appears to be just beginning, as to whether the phenomena upon which the action of the photophone depends are to be traced to the action of light or of heat, or to a form of radiant energy which may be separated from either or both.—*Engineering.*

THE BRITISH GOVERNMENT AND THE TELEPHONE.

THE contest between the Government and the Edison Telephone Company is at last concluded, and (unless the decision be reversed on the appeal) the Post Office monopoly has been clearly established, not only in the matter of telephonic telegraphy, as it at present exists, but in all the various developments and improvements which will inevitably be made in that science of communication at a distance in which a wire connects the transmitting and receiving instruments. From the beginning it was difficult to understand how any different result could be arrived at than that announced by Mr. Justice Stephen on Monday last; and during the course of the trial it was evident that the delicate reasoning of the defense was such as could not weigh against the formidable arguments of the prosecution. The action was especially interesting on account of the numerous affidavits as well as the evidence of such men as Sir William Thomson, Professor Adams, Dr. Hopkinson, Mr. Siemens, and others, but as Mr. Justice Stephen pointed out on several occasions, the question before the court was not that of refined distinctions in science, but the interpretation of acts of Parliament, and the wording of these acts is so clear and comprehensive, that, although of course the telephone was undreamed of when they were framed, no ingenuity on the part of the defense could demonstrate that, in the minds of the judges, the Edison Company was not infringing the monopoly of the Post Office.

It is evident that the decision, if confirmed, must check all private enterprise in the establishment of telephone exchanges, and this fact is very generally regarded with dismay, partly from a feeling of dislike to the existence of a Government monopoly, but chiefly because it is feared that the great inducements to scientific inventors will have ceased to exist, in other words, that so much money cannot be made out of the Government as the public, and that "invention will languish" in consequence. As regards the first objection this is not the place to discuss whether the policy which handed the telegraph system of the country over to the Government was sound or unsound, moreover the fact remains that it has been handed over, and the Post Office department is bound to do its best to protect the public interests, and to make the most profitable return for the large public capital invested in the telegraphs. That it is earnestly and honesty doing its best in both these directions, is, we think, shown by its action in the recent suit, the result of which is that the public will now be able to use the telephone for about 25 per cent. less than the rates at present charged by the private companies, and moreover all danger is averted of the future coalition of such private companies into a ring which should force the Government to buy them up in the more or less near future. As for the fear that invention is to "languish" through the result of this suit, it must be borne in mind that there can be little danger of the Post Office department employing its prerogative and depriving inventors of their fair remuneration, while the particular field of invention whence the telephone springs belongs to the realms of science rather than of commerce, the laborers in which are actuated by the love of science more than by that of gain. It must not be forgotten too, that England forms but a very small portion of the world, which is wide enough to satisfy the most ambitious inventor's desire, and should he be fortunate enough to possess the indorsement of the Post Office, he can find but few difficulties elsewhere. An incidental but not unimportant advantage is secured to the public by the recent action of the Crown. Although the establishment of telephones in London has only just begun, a sensible danger has been created by the reckless manner in which wires are stretched across the streets of the metropolis, and this danger would continue to increase rapidly with the extensions of private companies. In the hands of the Post Office, however, the danger will cease, as all care will be taken to lay the wires so as to afford perfect security.

We said just now that an important economy would be secured to the public by the prices at which telephones will be supplied. The charge of £15 per annum for all distances within half a mile of a telegraph center, will practically be the rate which the inhabitants of the metropolis using the telephone will have to pay, and this rate will doubtless be decreased as time goes on. Moreover, the system of dispatching provincial telegrams direct from the office of the transmitter will prove a great convenience, while delivering messages direct by telephone will effect a saving of one halfpenny for each telegram so delivered, an economy which will form no mean addition to the postal revenue. That the department has lost no time in establishing the telephone system is shown by the fact that they have ordered 20,000 telephones of the Gower-Bell Telephone Company, having satisfied themselves, after long trial, that this instrument is best adapted for their requirements. This will necessarily be only a small part of the total requirements, but it will be sufficient to popularize the use of the instrument, and to make it what it has become in the United States, an almost universal necessity. We notice that the United Telephone

* *Journ. Soc. Telegraph Engineers*, vol. vi., page 423.

* *Journ. Soc. Telegraph Engineers*, vol. vii., page 234.

* "On the Action of Light on the Electrical Resistance of Selenium." By Lieutenant Sale, R.E. "Proceedings Royal Society," vol. xxi., page 238.

Company has solemnly warned the British public that if it employs any form of carbon receiver or electro-chemical transmitter protected by the patents of Professor Bell and Mr. Edison, it will be liable to the penalties of the law. This threat is not a very terrible one, because the Post Office does not appear to have the least intention of using these instruments, and because, if they did, such instruments would be Crown property. The Government moreover would undoubtedly hold all hirers harmless, and take on themselves the responsibilities of legal action.—*Engineering.*

THE AMERICAN RAPID TELEGRAPH IN ENGLAND.

AT the recent meeting of the Society of Telegraph Engineers there was exhibited for the first time in Europe one of the new "American rapid" or "electro-mechanical" telegraph instruments, the latest and most expeditious resuscitation of the original Bain system.

The apparatus consists of a puncher for perforating the message on a strip of paper after the manner of Wheatstone's automatic. The puncher is an elaborate apparatus very much larger than the small Wheatstone puncher, and the paper is punched by the operator sitting in front of a keyboard and playing upon a double row of keys like those of a piano. The work of punching can thus be performed with greater ease than with the Wheatstone puncher, if not with greater speed, and in America female telegraphists are employed for the work. The punched paper is then passed through the transmitter, and the signal currents are sent by two pointed spring contacts dropping through the holes in the paper on to a metal wheel or pulley, over which the paper is rapidly whisked by turning a revolving handle. The turning of this handle is therefore all that the operator requires to do in the act of sending a message.

The distinguishing feature of the rapid telegraph, and the source of its high speed, is the absence of spaces between each signal current composing a letter. In the old system, as is well known, each signal current of a letter or "dot" and "dash," is separated from its next neighbor by a space; and, of course, much time is lost in transmitting these gaps. In the new system the spaces are avoided by causing the receiver to mark the successive signals of the letter at opposite sides of the axis of the moving paper. Thus by the simple device of placing the signals in double file, the time lost in separating them by longitudinal spaces when placed in single file is saved, for the end of one signal may coincide in point of time with the beginning of the next, although the signals are rendered quite distinct by their side-by-side position. This arrangement will be best understood by a reference to the following diagram, which represents a portion of a message as received, with the corresponding punched slip beneath:

FIG. 1.

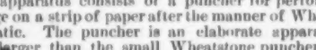
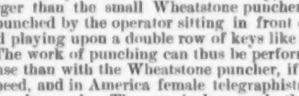


FIG. 2.



The signals themselves are dots and dashes, the latter being shorter than is usually the custom, and the space between each two *letters* is marked by a longer dash.

The transmission of the signal currents is effected by employing two batteries, one having its copper pole to line, and the other its zinc pole. The double row of holes in the punched paper transmit alternate currents from these two batteries into the line by means of the two spring points which make contact with the metal pulley over which the paper passes whenever a perforation in the paper allows them to do so. For this purpose the pulley is made double, so that there is one point to each distinct half of the wheel. When it is known that each half of the wheel is connected to its own battery, and that both the points are connected to the line, the course of the current will be readily understood.

The marking of the message is effected in the receiver by a modification of Bain's electro-chemical process. The currents pass from the line to a pair of pointed steel styluses, which rest side by side upon a traveling slip of paper, which has been impregnated with a solution of equal parts of nitrate of ammonia and ferrocyanide of potassium. From these styluses they pass through the paper to a metal pulley beneath, and thence to earth. In passing through the prepared paper, the currents decompose the chemical solution with which it is moistened, and stain the track of the styluses with a succession of dots and dashes, the shorter currents marking dots, and the longer ones dashes. The blue stains are due to the formation of Prussian blue.

The American rapid telegraph is the invention of Messrs. Theodore M. Foote, C. A. Randall, and Frank Anderson, and was first put into practical operation on the 19th July last, between Boston and New York. The ordinary rate of working over this line, a distance of 250 miles, is 1,000 words per minute, but the apparatus can readily work up to 1,800 words per minute. The American Rapid Telegraph Company is succeeding so well with it that, though they began business so recently, they will soon possess their own lines from New York to Washington, Cincinnati, and Chicago.

A practical trial of the apparatus has been made on some of the longer English lines by Mr. W. H. Preece; but the induction which is so strong on our lines has reduced the speed of working considerably, and lengthened out the signals by its retarding effect. In fact it has not proved so rapid as the Wheatstone system now employed by the Government electricians, and in the meantime the use of the apparatus is in abeyance. On the American line there is little or no induction, owing to the fact that it has been as yet operated along a line carrying only one wire; but the inventors hope yet to improve its speed on English lines. The apparatus shown at the Society of Telegraph Engineers has, we believe, been taken over to Paris, in order to try it on the Submarine Company's line from Paris to London.—*Engineering.*

A TEA plantation was established last year by Count d'Amigo upon his estates, situated near Messina. The tea plant is said to thrive perfectly well there, and its leaves are said to be in no wise inferior to those of the Chinese plant. In order to dry them in a rational manner and to prepare them for export as well as for home consumption, a Chinese expert is to become the manager of the Messina plantations.

SOUND FROM RADIANT ENERGY.

THE announcement that Mr. W. H. Preece the President of the Society of Telegraph Engineers, would lecture on the "Photophone and the Conversion of Radiant Energy into Sound," attracted a large number of auditors to the hall of the Institution of Civil Engineers on Wednesday, December 8. This was partly due to the intrinsic interest of the subject coupled with the well known ability of the lecturer, and partly to the fact that Professor Bell himself was expected to be present. Mr. Preece began his discourse by a reference to the other three great inventions of the last four years: the telephone, the phonograph, and the microphone, all of which, together with the latest marvel, the photophone itself, were concerned in the transmission and reproduction of sound.

After explaining that sound was a sensation caused by a vibratory motion in the air communicating itself to the drum of the ear, he illustrated the composite nature of light by throwing a splendid spectrum on the screen with the help of Mr. Ladd. Light, he observed, is a sensation of the eye set up by the action of a vibratory motion in the luminiferous ether. The telephone owes its action to an electric current varying in sympathy with the vibrations of the air constituting sound, and it is clear that if a substance could be got which, under the influence of light, would vary an electric current passing through a telephone, the transmission of sound to a distance by means of a vibratory beam would be rendered feasible. Such a substance is selenium, a body discovered in the year 18 7 by Berzelius, when he was looking for tellurium, but it is so intractable in its physical properties that Professor Bell has had to overcome a great many practical difficulties in adapting it to his purpose.

We have so recently described the genesis of the photophone and its actual construction that it will be unnecessary for us to follow Mr. Preece at length. We shall rather aim at presenting the most novel parts of his lecture and the fresh ideas it evoked in the discussion. The history of selenium is in a physical sense very interesting. It is an instance of a little known and somewhat ambiguous mineral, neither metal nor non-metal, which by virtue of a peculiar property, accidentally discovered by Mr. Willoughby Smith, has been chosen from among its fellows and exalted into honor. While seeking for a convenient form of high resistance to be used in cable testing, Mr. Willoughby Smith found that the exposure of a piece of selenium to light generated an electric effect in it which could either be attributed to a diminution of its electrical resistance, or to the creation of a current in the material. This original experiment was exhibited to the meeting by Mr. Willoughby Smith with the aid of a box which could admit or exclude the light from a piece of crystalline selenium connected in circuit with a battery and a reflecting galvanometer. The light of a lucifer match falling on the selenium was sufficient to deflect the light spot off the scale.

Mr. Willoughby Smith's discovery gave rise to the questions whether the effect was due to the light, heat, or active rays of the spectrum, and whether it was a diminution of resistance or a new current excited. With regard to the first question, all subsequent investigators have shown it to be due to light rays, Professor W. Grylls Adams and Professor Bell attributing it chiefly to the yellowish-green or middle rays of the spectrum, and Lieutenant Sale to the red rays. With regard to the second question Professor Adams has distinctly proved that a current is really set up in the selenium by the action of light, without a battery at all being in the circuit—a discovery confirmed by Mr. W. Crookes. The last mentioned investigator coated the vanes of a radiometer on one side with chromic oxide, and on the other with selenium, and found that in May of one year they rotated in a certain direction under the influence of light, while in October of the same year their rotation was in the opposite direction. In searching for the cause of this peculiar behavior he traced it to the use of a sperm candle giving a white flame and making the selenium surfaces to retreat on the one occasion, and the use of a wax candle giving a yellow flame making the chromic oxide surfaces to retreat on the other occasion. Here, then, we have two substances differently affected by rays of unequal refrangibility, the selenium being more sensitive to rays of higher refrangibility or smaller wave length. Mr. Robert Sabine's experiments with selenium have established the fact that by the action of light on that substance an electromotive force is set up at the surface on which it falls; and Professor Minchin, of Cooper's Hill College, has demonstrated that light falling on one of two tinfoil plates immersed in hard water generates a comparatively powerful current. These observations tended to show that the effect of light on selenium was to generate an electric current; but other experiments by Mr. Sabine and others had proved that there was also a diminution of resistance; and as Professor Adams remarked in the discussion, both effects are produced together, the diminution of resistance being the stronger effect, and it is that upon which the theory of the photophone is based.

The intractable nature of crystalline selenium, and its extremely variable resistance, were first discovered by Dr. Werner Siemens, who found the variation of its resistance under the influence of light to be proportional to the square root of the illuminating power of the light; but when he attempted to construct a photometer on this principle he was met with disappointment owing to the uncertain resistance of the material. Two fragments of selenium from the same piece, prepared in precisely the same way, gave widely different results, and the same fragment altered from day to day. Professor Adams has observed that the resistance decreases by time, and instanced a piece which fell from 7,600,000 ohms in May, 1876, to 7·45 ohms in May, 1877. This liability to secular variation was one of Professor Bell's difficulties in working out the photophone; so, also, was the physical "fatigue" experienced by the mineral under the prolonged action of the light. This was early observed by Dr. C. W. Siemens, in experimenting with his "selenium eye," a simple apparatus consisting of a hollow ball containing a sensitive plate of selenium fixed in the focus of a lens in front of which are two movable shutters, these various parts corresponding respectively to the retina, the crystalline lens, and the eyelids of the human eye. The selenium plate is placed in circuit with a battery and galvanometer, and every time that light is admitted to the selenium by the opening of the eyelids, a corresponding deflection takes place in the galvanometer; the needle returning to its zero position when the light is again cut off. When the action is repeated often the selenium fails to respond as promptly as before, and the effect is lessened. This drawback had also to be overcome by Professor Bell. Various forms of selenium cell employed by him were illustrated by Mr. Preece, some of which we shall describe in our next issue.

The experiments which have led Professor Bell and Mr. Sumner Tainter to announce the discovery that all bodies are rendered sonorous under the influence of an intermittent or vibratory beam of light were very lucidly described by Professor Bell himself in opening the discussion. He explained how an intermittent beam of light, either luminous or deprived of its luminous rays by passage through a screen of ebonite, and allowed to fall on *thin* disks of any material, wood, paper, metal, gutta percha, glass, etc., caused the disks to give out a musical tone of a pitch depending on the number of intermissions per second, and of a *timbre* depending on the nature of the disk. Even tobacco smoke and crystals of sulphate of copper held in a test tube in the path of the intermittent beam emitted a corresponding tone, and even when the beam was simply focused within the outer ear itself, without any auxiliary appliances whatever, a note was likewise audible. In the short discussion which followed the lecture this conclusion of Professor Bell that all bodies are rendered sonorous by the fall of light in this manner, was pleasantly questioned by Dr. Tyndall, who thought it might be due to the expansion caused by the impact of heat rays; and in support of his remarks he cited an experiment which he had made in presence of Professor Bell at the laboratory of the Royal Institution. He took the vapors of two volatile bodies, bisulphide of carbon and sulphurous ether, and exposed them successively in a glass vessel to the intermittent beam of light; and he argued that if the effect was due to the absorption of heat and the consequent expansion of the vapor, an audible effect would be obtained from the sulphurous ether, while on the contrary, the bisulphide of carbon would give no effect owing to the fact that it is almost completely transparent to heat. The result was that the sulphurous ether yielded a distinct musical note, and the bisulphide of carbon was quite silent. So far, then, as this experiment goes, Professor Tyndall's surmise is correct; but the subject will have to be cross-examined by a variety of careful experiments ere the question can be set at rest.—*Engineering.*

MARITIME METEOROLOGY.

By THOMPSON B. MAURY, Phila.

1. *The Winds of the Globe* between the Arctic and Antarctic circles may be classified as two distinct systems. Within the tropics they blow from east to west, as Columbus noted on his first voyage to America. But within the temperate zones they blow generally from west to east. The winds in the middle latitudes are called "variables," in opposition to the constant trade winds; and are from S. W. in the north temperate zone and from N. W. in the south temperate zone. Their direction, however, is largely decided by the great, moving barometric waves and storm centers.

2. *The Winds of the Atlantic* are not influenced by any mountain chain skirting its shores, as the Andes, which exert so great an influence on the winds of the Pacific. American research shows that the N. E. trade-wind belt extends much further to the north on the eastern side of the Atlantic than near the American coast. The trade-wind belt is narrower about 40° W. than further eastward, except in summer. The direction of the trades is much more easterly in the western than in the eastern part of the Atlantic. The S. E. trade is drawn across the equator and gradually changed into a S. and S. W. wind, densely charged with moisture. Between the Cape of Good Hope and Cape St. Roque is a peculiar streak of powerful S. E. trades.

3. *The Winds of the Atlantic Coast of North America*, from Labrador to Florida, are mostly S. W. in summer and N. W. in winter. In summer, however, they are more southerly and southeasterly near Florida than in New England, and in winter more frequently N. W. in New England than in the Middle and South Atlantic States. In autumn they are more northerly in the South Atlantic States than in winter. From New York to Virginia the prevailing direction is W. S. W., inclining most to the north in February, and most to the south in August.

In the *Gulf of Mexico* the winds on the northern shore are rather N. E. in autumn; but S. and S. E. in spring and summer, when they are more regular than the northeasterly winds of winter. "*Northers*" occur from September to June.

HURRICANES OR CYCLONES.

1. Storms seem generally to *follow the course of the prevailing winds*, as eddies in running water travel *down stream*. In the tropics they move from east to west, on lines curving toward higher latitudes; when well past the tropics their paths incline to the eastward. Two storms, if near each other, tend to converge, and become more violent.

2. We know from the weather maps of the U. S. Army Signal Service, that American and Atlantic *storms travel in the long belt of low barometric pressure*, lying between the areas of high pressure, the space between serving as a *groove* for the passage of the cyclone. A storm center apparently cannot run through a bank of high pressure; when it meets such a bank it is delayed, or else goes around it.

3. A hurricane in passing over an island is apt to be broken up or weakened, and if it runs far inland is likely to lose its force or disappear. It needs much *vapor* to enable it to keep up its violence, and this it cannot get on land. As the process of evaporation from the sea surface is rapidly carried on, both by solar energy and by the agency of high westerly winds in the middle latitudes, and consequently aqueous vapor enormously supplied to passing storm centers, their intensity is greatest near the equatorial currents on their western sides, and in the middle latitudes where the counter trades blow most fiercely.

4. *Storms pursue the track over which rain is falling heavily.* At sea, therefore, when, with a falling barometer, a ship enters a *torrential* rain, she is probably in the track of an approaching gale. If rain falls in large quantities in any quadrant of a cyclone, the pressure will diminish and the violence of the gale will increase in that quadrant.

5. *United States Storms* generally advance from the Upper Mississippi Valley toward New York and New England, less frequently toward Virginia, and seldom toward the Carolinas. American storm centers most frequently pass off the coast between 45° and 50° N. latitude. When passing near Newfoundland, they often slow up.

6. *The Great Waves of High Barometer*, with fierce N. W. winds in their front, usually advance from the Rocky Mountains toward Virginia and the Carolinas, but less frequently toward New England. They mostly move S. E.

7. In an area of high barometer north of the equator the winds rotate in the same direction *as the hands of a clock*. In a cyclone they rotate apparently in a direction *contrary* to that of the hands of a clock. South of the equator these di-

rections are respectively reversed. There is generally a brief *calm* at the center of the hurricane. The cyclone must not be thought of only as a rotating disk, propelled mechanically from parallel to parallel; but also as an atmospheric *eddy*, which dies out in its rear but is rapidly renewed in its front, and thus propagated forward by the fall of the barometer.

8. *The Rate of a Hurricane's Advance* varies from 10 to 40 miles an hour, being slow in the tropics till it recurves. North Atlantic storms, according to American investigations, progress on an average about 15 miles an hour; near Newfoundland they are usually delayed, but after they pass it they increase in velocity and force. Cyclones seldom, if ever, cross the equator. In the West Indies, before recurving, their most dangerous winds are N. E. & E. N. E. While recurving, off the Bahamas and Florida, the highest winds are E., E. S. E., and S. E. Off the coast of the United States they are S. E. to N. E.

9. *The Shape of Cyclones* is seldom circular, but rather oval or elliptical, and their diameter (which is small in the tropics) is from 100 to 300 miles usually, after they get into higher latitude. Frequently cyclonic or other eddies seem to form and play around the borders of the main hurricane, from which they are offshoots.

10. Cyclones sometimes become *stationary*, and even go *backward*. When thus delayed, especially if in the vicinity of the Gulf Stream, or near warm open seas, on resuming their proper course they are more dangerous than they were before.

HINTS FOR HANDLING SHIPS IN OR NEAR CYCLONES.

1. *The Signs of a Hurricane's Approach* are, first, an increase of *ocean swell* from its forerunning storm wave, red or copper colored sky, lunar halo, sea rising in waves without wind and sometimes growing warmer with stronger smell. Threads of fine, wavy, cirrus cloud appear upon the S. W. horizon, moving apparently parallel to the horizon; an easterly wind springs up suddenly, when the higher clouds begin to move from a more southerly point. When these last occur north of the equator, a ship is directly in the storm track. The thermometer rises, and the barometer, after having first become unsteady, or *rising slightly*, begins to fall rapidly. With sultry, oppressive atmosphere, the sky is thick and hazy in the direction of the hurricane; the wind moans, becomes puffy, and blows in gusts, indicating that it is not far off. If from the cloud bank overhanging the storm, shreds of clouds are seen projected forward and upward, as if by some violent ascensional movement of air, the storm center is dangerously near.

But, perhaps, the most timely and trusty indication of a cyclone is often the rise of the thermometer coupled with a *reversal of the normal wind*. Thus, in the trade-wind belts, a fresh westerly wind suddenly springing up should at once arouse suspicion, particularly in the hurricane season, which in the West Indies, the China Sea, and Bay of Bengal is from July to October. Equally suspicious, is a strong easterly wind suddenly succeeding the normal westerly winds between 40° and 50° N., on the routes from the United States to Europe. Scarcely anything except the indraught of a deep depression can be supposed to cause the sudden change of the East Indian monsoon, in August and September. A cautious seaman, therefore, with his wind chart before him, may very frequently, it would seem, by attending to the *abnormal and sudden change of wind-direction*, foresee that he is in front of a revolving gale, though his barometer remains high, the sea smooth and none of the usual signs of hurricanes can be distinguished overhead.

The Mexican "Northers" are indicated by unusually fine precedent weather, a light bank of clouds in the north, followed perhaps by a faint northerly breeze, wind coming in puffs, and *barometer always rising*. After the norther has apparently ceased, it is dangerous to go to sea, unless the barometer has fallen to about 30 or 30·05 inches.

2. *The Winds within a Cyclone* do not blow in perfect circles, nor in straight lines, but rather in *irregular spirals*. They blow in a more circular direction on the outside of the cyclone than near its center. The nearer they get to the central area the more does their direction resemble that of the spokes of a wheel. In the North Atlantic there is reason to think the strongest storm winds are in the S. E. quadrant; in winter the strongest winds are probably oftener in the N. W. quadrant of the depression. The storm winds, though they are subjected to both a centrifugal and to a centripetal deflecting force, of course all incurve toward the storm center.

3. *To Find the Direction of the Center.*—The center does not always bear at right angles to the direction of the wind. In the Northern Hemisphere, with your face to the wind, the center is from 10 to 12 points to the right hand side. In the Southern Hemisphere the angle is to be measured to the left hand side; but in both Hemispheres it is to be reckoned in a direction opposite to the storm's rotation. In a word, running a line from the ship at an angle of about 60° or 65° with the wind direction, you will find the approximate bearing of the cyclone's center. If, however, the ship has already gotten into the gale, the angle may be much less than 60°, say 8 or 9 points.

As the winds do not blow in circles around the storm center, it will probably not be very far from the truth if we assume that, in both hemispheres, the higher storm winds (say of force 6, velocity 45 miles an hour) make with a line drawn from the ship to the center, an angle of about 45°. Lighter winds make a greater angle, and those of force 7, velocity 60 miles an hour, a lesser angle. These figures are, of course, somewhat conjectural, and the angles made very variable. But, as rough approximations, they may give some idea of the general bearing of the center of danger. In fine, we can only tell on which side of the gale the ship is, by carefully noting the shifts of the wind; always remembering that, if it does not shift decidedly, the ship is dangerously near to, or in the storm's track.

4. *To Avoid the Center of a Cyclone*, the most important point is *not to run before the wind*, which blows toward the center. For ships known to be in front of a Northern Hemisphere hurricane and on its track, the best rule is to keep the wind well on the *starboard* quarter. In south latitude, the wind should be kept well on the *port* quarter, if the ship is known to be anywhere in front of a typhoon or hurricane. This rule holds good generally, and the wind should be kept on the ship's quarter as much as it is possible without causing her "broaching to." To carry on with a fair wind when haze, sea swell, and sky-indications show that the ship is threatened by a gale, is unjustifiable; far better to "heave to" and watch the sky, wind, sea, and barometer.

All positive rules, of course, are defective, and if blindly carried out, may be very dangerous to the mariner. But, in the present state of ocean meteorology, the most trustworthy data substantially sustain the above deductions. By keeping on the port tack and running or scudding directly with the wind, in front of a North Atlantic cyclone, a ship must almost certainly get entangled in its central disturbance. By keeping the wind on the starboard quarter, as well as circumstances permit, and her sea room will justify, she will usually be most likely to edge her way toward a calmer sea and a clearer sky.

Supposing then a navigator has good reason to believe that he is running some distance in front of a North Atlantic hurricane, let him look the wind square *in the face, and measure round to his right hand side about* 12 *points* of the compass. The twelfth point will indicate approximately the direction of the center. Knowing where the chief danger lies, he can act accordingly. As hurricanes are sometimes impelled or propagated forward from 40 to 50 miles an hour, it is unsafe to attempt to cross the path in front of the depression.

5. As the cyclonic winds probably blow harder and more directly toward the center the nearer they get to the central vortex, it is more necessary that *a ship should increase her distance from the center in the very beginning of the gale*, when it is more practicable to keep the wind on her quarter. A ship running before the wind will sometimes have the storm center bearing about 25° or 30° (2 or 3 points) before her port beam; hence she will be running into the most dangerous part of the storm. A distance of ten miles may occasionally (especially if the ship is near the West Indies) make all the difference between losing a few spars and foundering.

As the westerly winds that rush in behind a retreating depression are offshoots from high pressure waves, moving from high to low latitudes, it seems clear that *after a storm center passes a ship*, the more northing she can make in the N. Hemisphere (and the more southing in the S. Hemisphere), the lighter will be the force of the winds, the less westerly will they be, and the sooner will she find a moderate sea.

6. A course for avoiding the heart of a storm is not all to be considered; at the outset of the gale the vessel should be put on a course most favorable for safely encountering the unavoidable after-part of the gale, and for the ultimate prosecution of her voyage. Such a variable course seems often to be preferred, as will enable her safely to meet, or to *render available the succeeding changes of wind.*

7. As cyclones sometimes remain stationary, and even return on their paths, it is *unsafe to follow closely on their heels*, in hope of profiting by the storm winds.

If a vessel is *caught in the center* of a hurricane and compelled to lie to, there seems to be no course better than to heave to on the starboard tack in north latitude (and on the opposite tack in south latitude), taking every precaution possible to meet the N. N. W. or N. W. winds that may be expected very quickly to burst forth. But no absolute rule can be laid down to meet this case. By watching the tendency to shift which the wind manifests, we can tell very nearly what the subsequent violent and perilous shifts will be; and this suggestion must be a seaman's guide.

RESEARCHES IN OCEAN METEOROLOGY.

The United States Government is conducting an extensive system of ocean as well as of land meteorological observations through its Army Signal Service. It seeks the co-operation of all navigators, requesting them to take one observation every day at a prescribed moment, which is simultaneous for every part of the globe. These simultaneous observations are charted and published by the Signal Service at Washington, in its International Weather Charts and Bulletins, copies of which, with other publications of the Signal Service, are sent regularly by mail, without charge, to every seaman taking the observations and forwarding them to the Chief Signal Officer U. S. A., Washington, D. C. By entering into this arrangement and taking part in the observational work, every seaman may contribute materially to this scientific enterprise, and further the elucidation of the "law of storms," as well as securing for his own use a large supply of valuable nautical information. Blanks for entering the observations (and instruments also, if necessary) are furnished to ship captains; and it is hoped that all captains interested in meteorology will enlist in this service.—*Abridgment of Nautical Almanac.*

THE HURRICANE AT SITKA.

AT a recent meeting of the California Academy of Sciences a paper by Commander Henry Glass, of the U. S. S. Jamestown, now at Sitka, was read by Mr. Brooks. The hurricane took place October 20, 1880. Careful observations were made on board the Jamestown every ten minutes, of the height of the barometric temperature of the air, force, and direction of the wind, and forms and general movement of the clouds. At 10h. 35m., October 25, the barometer stood at 28·2), the wind blowing in terrific squalls, accompanied by rain. The wind marked 11 to 12, in the Beaufort system of notation. The temperature of the air fell from 53° to 44° Fah. The first indications of the gale were noted October 23, from which time the barometer gradually fell. The rotary column of the hurricane advanced at the rate of five to six miles per hour, and its course was determined by the configuration of the high land, the storm extending only 1,000 ft. high, to which height trees on the hillsides were prostrate, and above which they escaped injury. A heavy shock of earthquake occurred as the storm-center passed over the southern flank of Mount Edgecumbe, an apparently extinct volcano, whose ancient crater was then exposed to the area of lowest barometrical pressure. Commander Glass inquires, Did the sudden removal of an enormous atmospheric pressure over the crater of a recent volcano offer sufficient cause to account for the shock of earthquake noted simultaneously with the lowest barometric observation? He thinks there was something more than a mere coincidence in this awakening of seismic activity. Several shocks succeeded, gradually decreasing in severity, in close correspondence with the rise of the barometer to its normal height in that latitude. Reports from the interior prove beyond question that Mount Edgecumbe was the center of oscillation, decreasing in severity as their distance from Sitka increased. He concluded by requesting the Academy to scientifically investigate the important question of the relation of hurricanes and earthquakes, as indicated by their coincidence with areas of low barometric pressure or high electric tension.

THE report of the Comptroller of Nevada shows that the taxable valuation of that bonanza State is only $27,598,658, or about that of an ordinary eastern city of thirty or forty thousand inhabitants. The total tax derived from the mines of the State is only $115,169.

SULPHATE OF SODA BY THE DIRECT PROCESS.*

By JOHN HARGREAVES.

IN compliance with the invitation of our Secretary, I have the pleasure of placing before you the following paper on the manufacture of sulphate of soda by the Hargreaves and Robinson direct process.

This process was first brought before the public about ten years ago, and since that time has slowly but surely made its way, its superiority over the old process being now clearly established in every point.

As the chemistry of the process is so well known, I will confine myself exclusively to its technicalities.

The first working apparatus erected consisted of four brick chambers of 6 feet cube. With this arrangement difficulties arose in consequence of leakage of the gases from one chamber to another without passing through the columns of salt, from the chambers into the flues, and *vice versa*. These, together with the leakage of air, necessitated a very large consumption of fuel. To overcome these evils a second experimental apparatus—consisting of 4 cast iron cylinders, each 10 feet diameter by 10 feet high—was erected in a double line. This practically got rid of the leakage. But the small amount of material and the shortness of the column, together with a relatively large amount of radiating surface, showed the advisability of increasing the size of the apparatus. With this object two other cylinders of the same dimensions were added to the series. This addition, although giving improved results, still fell short of the object in view, and the cylinders were afterward pulled down.

The next apparatus consisted of 8 cylinders of 12 feet diameter, by 12 feet high, which were erected in a single line: each cylinder having two fire places and two discharging doors placed on opposite sides. The sulphurous acid pipe was placed on one side, and the circulating pipe connecting each of the end cylinders on the other side of the line of cylinders.

This arrangement gave a long column of salt, but exposed too much cooling surface, and consumed more fuel than was desirable. But this was afterward greatly reduced by erecting another line of eight cylinders, so arranged as to form a double row with one fire place and one discharging door to each cylinder. This reduced the fuel to about one-eighth of that previously required per ton of sulphate, for, while the production of the plant was doubled, the total fuel consumption was reduced to about one-fourth. This most remarkable result was another confirmation of the fact that the larger the quantity of material operated upon the smaller the proportion of fuel required.

Four sets of plant, having a total of 38 cylinders of 15 feet diameter by 12 feet high, were next erected by several firms. Each set was arranged in two rows with an archway betwixt, having two fires and two drawing doors to each cylinder for the convenience of quick discharging and reheating. Twenty cylinders of the same size, but arranged back to back, and with only one fire place and drawing-place to each cylinder, were afterward erected by the Atlas Chemical Company. The working of these cylinders proved that it was quite practicable to discharge the contents of each through one drawing-door. All the foregoing experience pointed in the direction of still further increasing the dimensions of the cylinders, and arranging the apparatus compactly, so as not to expose an excessive amount of radiating surface. Convinced of this fact, the same firm decided to erect another set of cylinders of larger dimensions than any yet attempted—viz., twelve cylinders of 18 feet diameter by 12 feet high, each containing 55 to 60 tons of sulphate. Several important improvements were introduced into this apparatus. In the previously erected plants the gas, after descending through the mass of partly converted sulphate, was conducted from the bottom of each cylinder to the top of the next by means of an external pipe connected to the lower part of the cylinder. In this apparatus these external pipes are replaced by D-shaped pipes arranged in the interior of the cylinders, by which leakage of air into the upcast pipe is entirely prevented, and, besides, has the advantage of placing all the connecting joints at the top of the cylinders where they can be got at. The brickwork is also simplified, and now consists of a 9 inch ring around each cylinder, with an outer wall inclosing the whole series, the remaining spaces other than the fire-places and flues being filled up with concrete to prevent loss of heat. The hydrochloric acid is taken from the top of the circulating pipe through a movable wrought iron siphon to a pipe fixed above the two lines of cylinders. This has considerable advantages over the earlier system of taking the exit gases through the drawing-doors, and thence by an underground flue to the exhausters, as it effects considerable economy in the amount of iron used in construction, and decreases the number of joints.

This plant also contains the recently-improved firing arrangements, by which the heat from the fire-places is more evenly distributed, and local heating of the cylinders rendered almost impossible, no matter how carelessly the workman may fire.

Respecting the question of fuel required to maintain the temperature of the cylinders, I may here note that one of the best conducted plants is now fired almost exclusively, not with coal, but cinders obtained by riddling the ashes from other furnaces in the works, and of this inferior fuel less than 2½ hundredweight is required per ton of sulphate made, and consequently the cost of repairs to fire-places is almost *nil*.

The salt was originally prepared by moistening with water, and forming into lumps by drying on floors heated from beneath, and afterwards broken into small pieces by a mill. This preparation is now performed entirely by machinery. The moistening is effected by the waste steam from the engine supplying the motive power. This steam passes into a box in which the salt is agitated by revolving arms. It then passes on to an endless band formed of a series of iron plates, where it is stamped and cut into suitable pieces. It then enters the drying oven, where, after being brought into direct contact with the products of combustion, it arrives at the other end in a suitable condition for putting into the cylinders. It is important that the prepared salt be sufficiently porous to allow the diffusion of the gaseous reagents, and also free from dust, so as not to close the passages through which the gases circulate in traversing the cylinders.

The kind of salt varies with the purpose for which the sulphate is required. Ground rock, surface evaporated salt, sweepings from salt works, and other cheap sources of salt are largely used for the process where sulphate is made for alkali manufacture.

When it is required to use the sulphate without refining

* A paper read before the Faraday Club, Liverpool, Dec. 13th, 1880.

for the manufacture of plate glass, it is necessary to use salt containing only traces of iron.

The salt prepared by Mr. Otto Pohl's method works exceedingly well in the direct process. His system consists in evaporating the brine by bringing the products of combustion into direct contact with it in one vessel, while above there is a pan in which another quantity of brine is heated from below. It is found much more economical than the ordinary system of salt manufacture both as to fuel, labor, and working space, and, hence, affords a supply of salt at much lower cost. I have here samples of this salt kindly furnished by Mr. Pohl.

Any carbonaceous matter contained in salt used for the direct process is quickly burnt out in the cylinders, leaving a perfectly white sulphate.

When a cylinder is filled with salt it is made the exit of the series, and quickly becomes elevated to a working temperature (which may be estimated at 400° C.) by the hot gas coming from the previous cylinders, and also by the action of the small fire attached. As soon as the formation of sulphate commences, the temperature rises rapidly, rendering the further application of external heat unnecessary until—in consequence of the small amount of chloride remaining—the heat generated by chemical action diminishes.

As the salt becomes converted into sulphate it is brought nearer or nearer to the source of sulphurous acid, the proportion of which, passing the cylinder, increases daily until it becomes the first cylinder in the series, when it receives the red hot gas coming direct from the burners, which quickly decomposes the remaining chloride.

The time occupied in decomposing the contents of a cylinder varies with the kind of salt and the size of the pieces employed, but under ordinary circumstances should not exceed 21 days, and has often been done in less than 14 days.

When the charge is decomposed the cylinder is isolated by closing the dampers connecting it with the sulphurous pipe and the succeeding cylinder, which latter in its turn is made the first in the series. The drawing-door is now opened and the sulphate discharged; after which the cylinder is refilled, and again made the last in the series.

The amount of cubic capacity required in the cylinder per ton of sulphate per week is about 170 to 180 cubic feet.

The pyrites burners, with the exception of being better protected against heat losses, are the same as used in the old process.

The draught from the burners is obtained by means of exhausters placed on the passage from the cylinders to the condensers. The waste steam from the engine driving these, after passing through a superheating coil, heated by the waste products of combustion coming from the cylinder fires, is mixed with the sulphurous acid in the burners to supply the necessary water vapor for the decomposition of the chlorides. Besides being an economical source, this has the advantage of automatically regulating the supply of steam to the sulphurous acid, which must vary with the speed of the engine driving the exhausters.

Neither the hydrochloric nor sulphur acids have any appreciable effect upon the iron-work of the apparatus, as the temperature is always in excess of that required to keep them in the gaseous condition.

The condensers used are the same as in the old process, but, as the gas comes in a continuous stream, there is no necessity for the frequent variation of the supply of water to the condensers which is required to condense the acid from pots.

The advantages claimed are briefly as follows:

1st.—Although the cost of apparatus is about the same as that required for the old process, there is this difference: That whereas the life of a vitriol chamber may be estimated at, say, ten years, the cylinders used with ordinary care in the direct system show every sign of lasting three times that period without renewal.

2d.—Less fuel, being about one-half that required by the old process.

3d.—Less labor, and with the exception of the burner men, and one intelligent person to look after the plant, no skilled labor is required. Hence, less difficulty in dealing with the workmen.

4th.—Less repairs. In the instance of one apparatus which has been working several years, I am informed that this item is less than 6d. per ton of sulphate made.

5th.—No nitrate of soda necessary.

6th.—Cheaper qualities of salt—not available for the old process—are used.

7th.—Less sulphuric among the hydrochloric acid. Consequently less annoyance from sulphate of lime in the Weldon process.

8th.—No leakage of hydrochloric acid into the fire flues, the whole of it passing through the exhausters.

9th.—The sulphate when drawn emits no hydrochloric or sulphuric acid to annoy the workmen.

10th.—Sulphate is made containing only very small quantities of chloride and free acid, and, therefore, especially adapted for the manufacture of 76 per cent. or other high strength caustic, for which it is largely used. The manufacturers, while guaranteeing this quality to contain less than 0·5 per cent. chloride of sodium, often supply it with less than 0·2, and even as low as 0·05 per cent chloride. I need hardly say that sulphate of such a quality commands a decided preference over that made by the old process, and in practice sells for about 2s. 6d. per ton over the ordinary market rate.

Sulphate made by this process is also used without refining for the manufacture of plate glass, and is superseding that of the old process, which has to be refined at an additional cost of 35s. and upwards per ton before it is fit for this purpose

Lastly, a reduced cost of production, which may be fairly estimated at 15 to 20 per cent.

In conclusion, the process is now rapidly extending. Eight sets of apparatus are now at work, three others are in course of construction, giving an aggregate capacity of production of about sixty-seven thousand tons per annum. Arrangements are also being made for the immediate erection of additional apparatus.

A COLORING MATTER FROM CARBON DISULPHIDE.

By C. REICHL.

IF carbon disulphide is agitated with semi-fluid sodium amalgam, and if the paste-like mass is mixed with water, there is produced a hyacinth red liquid, while mercury and mercury sulphide are deposited. The solution contains the sodium salt of a yet unknown acid, somewhat soluble in hot water, and more readily in alcohol. It dyes yellow, orange, and brown shades on wool and silk.—*Polyt. Notizblatt.*

THE DETECTION OF STARCH AND DEXTRIN.

By SPENCER UMFREVILLE PICKERING, B.A. Oxon.

IN conducting some experiments in which it was necessary to ascertain the presence or absence of starch in a liquid containing various amounts of dextrin, the few facts here described were brought to light, and may, perhaps, be of sufficient interest to warrant their publication.

When a solution of starch which has been colored blue by the addition of iodine is heated, it is found that the temperature at which the color disappears varies with the intensity which it possessed before heating. Thus, for instance, 100 c.c. of a rather dark iodine-starch solution on being heated gradually in a flask became perfectly colorless at 58° C., and, on being cooled, showed a slight reappearance of color at 49° C., whereas an opaque blue solution did not lose its color till heated to 99° C., and became visibly colored again when cooled to 63° C. Similarly variable results were obtained by experimenting on iodine-starch solutions in sealed tubes, the temperatures of reappearance being much more constant (generally about 50° C.) than those of disappearance; this no doubt is due to the fact that, the stronger solutions having been heated to a higher temperature than the weaker ones in order to effect the disappearance, a greater quantity of the iodine present in them would have been converted into hydriodic acid, and this would tend to an equalization of the amounts of iodine present on cooling in the various cases. Owing to this conversion of iodine into hydriodic acid, the solutions on cooling, as might be expected, are considerably lighter than they were before heating, and their intensity naturally depends to a great extent on the rapidity with which they have been cooled; even a very weak iodine-starch solution which has been heated may be made to reassume its color if cooled very quickly.

The amount of starch which may be recognized by means of the iodine reaction varies, of course, with the bulk of liquid operated on. Using about 200 c.c., the weakest solution which gives an easily discernible blue tint in a beaker contains about 0·0001 per cent. of starch; while if small quantities are examined in a test tube this percentage must be doubled in order that the color may be rendered visible. The green color which is noticed when a large quantity of iodine is added to a weak solution of starch appears to be due simply to the combination of the proper yellow color of the free iodine with the blue color of the iodine-starch.

When two weak solutions of iodine, to one of which some starch has been added, are exposed to the air in an uncovered beaker, the iodine in both cases disappears entirely in the course of a few days, but more slowly from the solution which contains the starch; hence the iodine which disappears (owing partially to its volatilization into the air and partially to its hydrogenation) seems to be retained to a certain extent by the presence of starch. The presence of iodine has a reciprocal action in the preservation of starch. A solution of starch, which, in a few days, is converted into dextrin, may be preserved unaltered for a long time—possibly for an indefinite time, if an excess of iodine is present in it.

When a sufficient quantity of iodine is added to a solution of dextrin a deep-brown color is produced; the colored compound which is here present is in a state of true solution, whereas in the case of starch it will, as is well known, settle entirely to the bottom of the liquid in deep-blue flocks, leaving the supernatant solution quite colorless, and these flocks, on agitation, are disseminated again so as to form an apparent solution. The dextrin reaction with iodine is not nearly so delicate as that of starch; the weakest solution which gave any discernible color on being tested contained 0·005 per cent. of dextrin, and in this case the color could only be detected by using about 200 c.c. of the solution, and comparing the color with that of some iodine solution of the same strength as that to which the dextrin had been added.

With starch, the first drop of iodine which is added produces a permanent coloration. With dextrin, however, this is not the case; the color produced by the first drops disappears instantly and entirely. A considerable quantity must be added before a moderately permanent color is produced, and the reaction, owing to which the iodine disappears in this way, will continue for six or seven days. Whether the dextrin disappears or not at the same time has not been ascertained, although it seems most probable that it should do so.

When a solution of iodine-dextrin is heated the color becomes lighter and gradually disappears, as in the case of iodine-starch, but the temperature at which this disappearance takes place is considerably lower. An opaque brown solution on being heated in a flask became colorless at about 81° C., and, on cooling, regained its color with considerable diminution in intensity at 64° C. A solution of one-quarter the strength of the preceding one lost its color at 52°, and regained it on cooling at 34° C.; here also, as in the case of iodine-starch, we find that the colored principle does not become colorless at any particular temperature, but its disappearance is dependent on its original intensity.

The dextrin usually met with in commerce contains a considerable amount of starch, which, however, may be entirely converted into dextrin by prolonged heating at 140° to 160° C. for several hours, after which it gives the pure brown reaction with iodine above mentioned.

When iodine is added in excess to a mixture of starch and dextrin, the colors produced are blue, violet, purple, claret, red-brown, or brown, according to the various proportions in which the two substances are present. When the iodine is added gradually to the mixed solutions the colors produced, both temporary and permanent, follow the same order as those above mentioned, the blue colors appearing first, and the red ones only on the addition of larger amounts of iodine. Conversely, when the colored solution is allowed to stand, the red tints disappear first and the blue ones last. Obviously, therefore, the gradual addition of iodine affords an easy and delicate means of detecting starch in the presence of even a large amount of dextrin. Another way in which starch may be detected in similar cases is to add an ample sufficiency of iodine to produce a permanent color, and then to heat the liquid; the brown iodine-dextrin is decomposed at a comparatively low temperature, while the blue iodine-starch remains till the heat is raised considerably higher, and again, on cooling, the blue tint reappears long before the brown or red tint does; even when there is not sufficient starch to yield satisfactory results by this method, it may often be detected by the liquid being of a more bluish tint after the heating than it was before it.

O. Knab (*Chem. Centr. Blatt*, 1872, 492) found that some dextrin which he had prepared by repeated (ten times) precipitation with alcohol gave the reaction of a mixture of dextrin and starch, and hence concluded that it still contained some of this latter substance. It appears superfluous, however, to raise an impure preparation to the dignity of a chemical compound by giving it a distinct name—dextrin-starch—as Knab does. On leaving a mixture of solutions of starch and dextrin for some days, Knab found that, whereas the addition of iodine had at first caused a deep-blue coloration, after a time nothing but the red or brown color of iodine-dextrin was produced, and hence draws the somewhat startling conclusion that starch under the influence of dextrin is converted into dextrin. A simpler and more probable conclusion from these experiments would surely have been, that at the end of the few days during which his experiments lasted, the starch had suffered that spontaneous decomposition to which it is, as is well known, so prone, leaving in solution nothing which would give a coloration with iodine but the unaltered dextrin.

Dextrin and starch, it appears, give entirely different reactions with iodine; the former combines with the halogen to form a brown soluble substance, whereas the latter forms with it a deep blue insoluble body; and these two reactions are so distinct that presence of either of the reagents may be easily detected in a solution containing both of them.

The fact that the addition of iodine to dextrin produces only a transitory color at first, and that an excess of it is necessary to give a permanent tint, will, no doubt, explain the various discordant statements which exist as to whether any color is produced by the mixture of these two substances or not, and will probably render unnecessary the theory of there being two or three different dextrins as proposed by Mulder and by Griessmayer.—*Chem. News.*

HOW TO SOFTEN HARD WATER.

IT is now about forty years since Dr. Clarke invented the milk of lime process of softening waters rendered too hard for convenient and wholesome employment for domestic purposes by the quantity of carbonate of lime they contain in solution. The object of the process was to soften only, and for this purpose it has been employed for the treatment of the hard waters which alone are available at a number of the towns in England and elsewhere. The comparatively small cost of the process, however, ought to have led to its adoption in a very large number of towns where it has not yet been employed, not only on account of the economy resulting from the use of soft waters for laundry purposes, but because of the superior wholesomeness of water so treated for dietetic purposes. According to experiments made by the Rivers Pollution Commissioners 1 cwt. of lime will soften as much water as about 1 ton of soap, and the cost of the process per million gallons softened may be taken as that of 16 cwt. of lime, and about 7s. for labor. To this must be added interest on the cost of the mixing and settling tanks necessary for the purpose. The latter for large waterworks is rather heavy; but against this can be set the value of the chalk or whiting obtained from the water softened. Of this, about 2½ tons would be produced from a million gallons of Thames water, and of these 2½ tons, about one-half could be reburned and then used for softening another million gallons of water. After allowing for all costs in making the rest of the deposit into marketable whiting, the net cost of the process need not be more, according to the Rivers Pollution Commissioners, then 13s per million gallons, which is only about 2 per cent on the lowest charge in London for water, namely, 6d. per thousand gallons. With the tanks or reservoirs required, the total cost might be at the most 3 per cent. on the present price charged for water. The cost of the plant at the Plumstead Waterworks, where about one million gallons of water were softened per day, with the extra pumps which were in that case required, was under £4,600, the cost of the three reservoir agitators, pipes, and connections being £3,800 of this amount. These works were sold to the Kent Water Company in 1861, after the system had been in successful operation for seven years. Upon the Kent Company becoming possessed of the works the system was abandoned because the company did not wish to soften the whole of the water supplied from its works. Considerable complaint was made by the consumers, but the softening was never resumed by the Kent Company. While the process was in operation at Plumstead about 3½ tons of whiting were obtained for every ton of lime put into the water. This was sold as it was removed from the reservoirs to brickmakers, who fetched it away and paid 7s. per ton for it. More than three times the cost of the lime, at £1 per ton, was thus obtained for the resulting whiting. It will thus be seen that the cost of the process need not be more than that of the labor for mixing, etc., and interest on capital expended on reservoirs. The whiting is applicable to a great many purposes, and from its fineness and purity is of much higher quality and value than whiting produced in the ordinary manner. One objection to the process as carried out under Dr. Clarke's method is the cost of the reservoirs, and the time required for the subsidence of the chalk from the water. The subsidence takes from six to eight hours, and allowing for the cleaning out of each reservoir and placing in it the necessary charge of lime and lime water, about three hours are required, when three reservoirs, each holding about 360,0.0 gallons, are employed to deal with a million gallons of water. The necessary reservoir area is thus considerable and may be very large, and each reservoir is occupied about ten hours for each charge of water. The room occupied by the reservoirs is thus an objection to the system as well as their cost. For this reason endeavors have been made to dispense with these reservoirs by adopting the principle of Dr. Clarke's process, but substituting a continuous mixing and filtration for the intermittent mixing and subsidence. This process has now been in operation, as carried out for the Duke of Richmond and others, by Messrs. Atkins & Co., London, for a sufficient length of time to give ample proof of its practicability even on a large scale.

The process of Dr. Clarke has, as we have said, been employed almost solely for improvement of water by softening it. It is, however, most important to point out that the process is of the greatest value from another reason. It purifies the water it softens by removing a very considerable quantity of its organic impurities. This is a matter of much importance to all towns supplied with river water, and especially is of importance to remember the fact in connection with the London water supply question. The purification in this respect is well shown by the analysis of metropolitan waters, before and after softening, given by the Rivers Pollution Commissioners in their sixth report. The organic carbon and nitrogen in the Grand Junction Company's water, which were respectively represented by the figures 0·123 and 0·023 before softening, were reduced to 0·080 and 0·022 by the process, while the total solid impurity was reduced from 23·02 to 10·00, and the hardness from 17·6 to 3·6. Again, the water from the same source six months later, when softened and analyzed, gave organic carbon and nitrogen, 0·241 and 0·040 respectively, before softening, and 0·178 and 0·021 after softening. The Caterham water gave 0·028 and 0·009 before softening, and 0·045

and 0·003 after softening. The purifying effect is thus very marked, and affords the means of reducing the organic matter at least as low as that of Loch Katrine water, and producing nearly the same softness. The possible value of an application of the softening process in such a way that the large and costly reservoirs are unnecessary is thus very great, and those interested in water supply may see the system in operation at the Westminster Aquarium, where it has been in use a few months on a small scale, softening and filtering about a thousand gallons per hour for the fresh-water fish-tanks. The Thames water from the water company's mains is admitted into the usual supply cistern. From this a pipe conveys nine-tenths of the water used, directly to the top of a series of metal disks, where it is met by and mixed, by running over the disks, with the one-tenth of water which has passed through a tank containing slaked lime. The mixed waters then pass into a tank containing a filter, which consists of a series of disks covered with filter cloth, and is softened and filtered continuously for from eight to twelve hours. The filter is fitted with an arrangement of brushes in contact with each cloth-covered disk, and at the end of the above number of hours all that is necessary to be done in order to continue filtration for another period of ten hours, say, is to turn a handle, by which the brushes are caused to rub off all the whiting or spent lime and carbonate of lime from the water which has accumulated on the disks. The whiting is run off with a small quantity of water into a settling tank, where it hardens and is removed at convenience. Messrs Atkins have thus made it possible to treat Thames and other river water in such a way that all the advantages of Dr. Clarke's methods of softening may be secured without those disadvantages which have hitherto attended it. The softening effect of the process is not at all affected by the continuous method of applying it, as is shown by analyses of the water at Goodwood, which accompany a report of Mr. T. W. Keates, the consulting chemist to the Metropolitan Board of Works. The total hardness of this water is 17·6 degrees before softening by the continuous method, and 4·5 after it, while the water at the Aquarium is reduced from 17 to 6 degrees of hardness.

The value of the softening process has long enough been admitted, but the large reservoir area necessary has militated against its employment. If the mixing and filtering arrangement described can be used on the largest scale, as it is proposed it should be, it should not only afford the means of securing the economy and improvement of the water due to softening, and of reducing the sand filter-bed area required by the different London water companies, but should afford the means of largely removing those foreign matters from the Thames water which form the sole cause of complaint of those who do complain.—*The Engineer.*

HOT ICE.

AT a recent meeting of the London Chemical Society, Dr. Carnelly explained and performed his remarkable experiment of heating up ice, without melting it, by means of pressure.

Dr. Carnelly then explained the device which he had adopted in order to secure and maintain a vacuum in the case of ice. For the success of the experiment the tension must be below five millimeters. The apparatus consisted of a wide glass tube three-quarters inch in diameter, and about five to six feet high. This is placed in a vertical position, and is connected at its upper end with a strong glass flask placed horizontally, and surrounded with a freezing mixture. The apparatus having been inverted and filled with mercury, the lower end of the tube is closed with the thumb, and placed under the surface of a layer of mercury about ten inches deep. On withdrawing the thumb the mercury sinks in the tube to the barometric height, and a large Torricellian vacuum is obtained, which is surrounded, as far as the flask is concerned, with a freezing mixture. A small quantity of boiled water is now introduced, which rises to the top of the mercurial column, and surrounds the bulb of a thermometer suspended inside the tube. The water is then frozen, and the depth of the layer of mercury in which the tube stands reduced to about three inches; in consequence the mercury in the tube sinks, and leaves a detached column of ice with the thermometer bulb in its center. This column acts as a cork, shutting off the large vacuous space above from the small vacuum below. By carefully heating the tube the ice is melted round the circumference of the plug, and a fine annular opening is made between the ice and the inside of the glass tube. This restores the communication between the upper and lower portion of the vacuum. As soon as this is effected, any aqueous vapor which is formed is at once condensed by the freezing mixture, and the vacuum is kept intact. Under these circumstances the author has made the ice so hot that the thermometer in the center of the cylinder stood at 180° C. before the ice melted. In the experiment shown to the Society the thermometer only rose to 30° C., when the cylinder (which was too large and therefore too heavy) dropped off the thermometer. To prove that the ice was really hot the author has contrived and carried out some experiments, in which the cylinder of hot ice was dropped into a small calorimeter filled with water; the temperature rose when the ice was introduced, whereas if ordinary ice it would of course have been lowered. The author then showed two experiments with camphor and mercuric chloride, which were perfectly successful. The camphor was contained in a glass tube closed at one end and connected at the other with a Sprengel pump. On heating the tube the camphor melted, but on starting the Sprengel pump the camphor, as the pressure decreased, solidified, though the heating was continuous. The mercuric chloride was similarly raised many degrees above its ordinary melting point, when kept under diminished pressure, without liquefying; but on allowing the atmospheric pressure to enter, by cutting the tube, the solid mass immediately melted and began to boil.

Prof. McLeod suggested that the cylinder of ice might be used as its own calorimeter on admitting the atmospheric pressure. If the ice were at 180° C. it should liquefy into water at about 100°.

Prof. Ayrton pointed out that although these results seemed at first sight at variance with the experiments of Sir William Thomson and the well-known calculations of James Thomson, according to which an increase of pressure lowers the melting point, there was really no direct opposition between them, because the constants on which Carnot and James Thomson based their calculations were only constants at temperatures at and below 32°, and we had no evidence until these experiments of Dr Carnelly as to the value of these constants at higher temperatures. Under ordinary conditions an increase of pressure produces a slight diminution of the melting point, yet it was perfectly in accord with the principles of thermo-dynamics to suppose that at temperatures above 32° a slight diminution of pressure might enormously raise the melting point.

Mr. T. Brown said that he did not quite understand how removing the pressure from the outside of the ice could affect the ice in the interior, and it was difficult to see why the ice in the interior should not liquefy if raised to 180°, even if the diminution of pressure prevented the liquefaction of the surface layer.

A vote of thanks to Dr. Carnelly from a crowded meeting was then passed by acclamation.

SAPONIFICATION OF FATS.

By DR. VON DER BECKE.

THE name fat is generally applied to a mixture of the triglycerides of palmitic, stearic, and oleic acids. As regards the animal fats this assumption has been in all cases verified, but the vegetable fats display certain not unimportant deviations. J. König, J. Kiesow, and B. Aronheim, in saponifying vegetable fats, obtained invariably less glycerine than is required for forming the glycerine ethers of the fatty acids—a fact pointing to the conclusion that free fatty acids must be present, since the quantity of cholesterine occurring in the plants is too small to combine with the fatty acids. For saponification potassium and sodium hydrate were used along with the other basic oxides, the latter substances being considered equal in value to the former, the only difference being that the products in the one case are termed "soaps," and in the other "plasters." It was assumed hitherto that the triglycerides, like other ethers, were completely decomposed by the above-named ethers into salts of the fatty acids and glycerine, and that equal quantities of glycerine were obtained in all cases. For the saponification of fats and the separation of the products, J. König had proposed a process which consists essentially in treating the fat operated upon with an excess of lead oxide in presence of water at 90° to 100°. The author when attempting at his request to saponify cacao butter in this manner—in order to discover a process detecting the sophistications of this product—found that it could not be saponified with lead oxide, at least not in this manner. It was found on further experimentation that the quantity of glycerine obtained on saponification with potassium hydrate was in all cases considerably the highest. In the easily saponifiable fats, butter, lard, and olive oil, the difference was found less manifest, but it was much more distinct in those which are hard to saponify. Cacao butter and tallow, if saponified with lead oxide, yield scarcely traces of glycerine. A mixture of an easily saponifiable fat-like butter with cacao butter gave the same quantity of glycerine as if butter alone were employed. It is possible that the reaction when once set up may extend itself. Hence, it appears that in the case of some fats the method of saponification with oxide is not trustworthy, and that when the accurate determination of the proportion of glycerine in a fat is required, the saponification must be effected with potassium hydrate.

ON HEAT CONDUCTION IN HIGHLY RAREFIED AIR.*

By WILLIAM CROOKES, F.R.S.

THE transfer of heat across air of different densities has been examined by various experimentalists, the general result being that heat conduction is almost independent of pressure. Winkelmann (*Pogg. Ann.*, 1875, 76) measured the velocity of cooling of a thermometer in a vessel filled with the gas to be examined. The difficulty of these experiments lies in the circumstance that the cooling is caused not only by the conduction of the gas which surrounds the cooling body, but that also the currents of the gas, and, above all, radiation, play an important part. Winkelmann eliminated the action of currents by altering the pressure of the gas between 760 and 1 millimeter (with decreasing pressure the action of gas currents becomes less); and he obtained data for eliminating the action of radiation by varying the dimensions of the outer vessel. He found that, whereas a lowering of the pressure from 760 to 91·4 millimeters, there was a change of only 1·4 per cent. in the value for the velocity of cooling; on further diminution of the pressure to 4·7 millimeters there was a further decrease of 11 per cent., and this decrease continued when the pressure was further lowered to 1·92 millimeters.

About the same time Kundt and Warburg (*Pogg. Ann.*, 1874, 5) carried out similar experiments, increasing the exhaustion to much higher points, but without giving measurements of the pressure below one millimeter. They inclosed a thermometer in a glass bulb connected with a mercury pump, and heated it to a higher temperature than the highest point at which observations were to be taken; then left it to itself, and noted the time it took to fall through a certain number of degrees. They found that between 10 millimeters and 1 millimeter the time of cooling from 60° to 20° was independent of the pressure; on the contrary, at 150 millimeters pressure the rate was one-and-a-half times as great as at 750 millimeters. Many precautions were taken to secure accuracy, but no measurements of higher exhaustions being given the results lack quantitative value.

It appears, therefore, that a thermometer cools slower in a so-called vacuum than in air of atmospheric pressure. In dense air convection currents have a considerable share in the action, but the law of cooling in vacua so high that we may neglect convection has not to my knowledge been determined. Some years ago Professor Stokes suggested to me to examine this point, but finding that Kundt and Warburg were working in the same direction it was not thought worth going over the same ground, and the experiments were only tried up to a certain point, and then set aside. The data which these experiments would have given are now required for the discussion of some results on the viscosity of gases, which I hope to lay before the society in the course of a few weeks; I have therefore completed them so as to embody the results in the form of a short paper.

An accurate thermometer with pretty open scale was inclosed in a 1½ inch glass globe, the bulb of the thermometer being in the center, and the stem being inclosed in the tube leading from the glass globe to the pump.

Experiments were tried in two ways:

I. The glass globe (at the various exhaustions) was immersed in nearly boiling water, and when the temperature was stationary it was taken out, wiped dry, and allowed to cool in the air, the number of seconds occupied for each sink of 5° being noted.

II. The globe was first brought to a uniform temperature in a vessel of water at 25°, and was then suddenly plunged into a large vessel of water at 65°. The bulk of hot water was such that the temperature remained sensibly the same during the continuance of each experiment. The number of seconds required for the thermometer to rise from 25° to 50° was registered as in the first case.

It was found that the second form of experiment gave the most uniform results; the method by cooling being less accurate, owing to currents of air in the room, etc.

The results are embodied in the following table:

(Rate of Heating from 25° to 50°.)

TABLE I.

Pressure.	Temperature.	Seconds occupied in rising each 5°.	Total number of seconds occupied.
760 millims.	25°	0	0
	25 to 30	15	15
	30 to 35	18	33
	35 to 40	22	55
	40 to 45	27	82
	45 to 50	39	121
1 millim.	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	25	68
	40 to 45	34	102
	45 to 50	48	150
690 M.*	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	29	72
	40 to 45	37	109
	45 to 50	53	162
117 M.	25°	0	0
	25 to 30	23	23
	30 to 35	23	46
	35 to 40	32	78
	40 to 45	44	122
	45 to 50	61	183
59 M.	25°	0	0
	25 to 30	25	25
	30 to 35	30	55
	35 to 40	36	91
	40 to 45	45	136
	45 to 50	67	203
23 M.	25°	0	0
	25 to 30	28	28
	30 to 35	33	61
	35 to 40	41	102
	40 to 45	55	157
	45 to 50	70	227
12 M.	25°	0	0
	25 to 30	30	30
	30 to 35	37	67
	35 to 40	41	108
	40 to 45	58	166
	45 to 50	86	252
5 M.	25°	0	0
	25 to 30	38	38
	30 to 35	43	81
	35 to 40	54	135
	40 to 45	71	206
	45 to 50	116	322
2 M.	25°	0	0
	25 to 30	41	41
	30 to 35	51	92
	35 to 40	65	157
	40 to 45	90	247
	45 to 50	165	412

* M= millionth of an atmosphere.

There are two ways in which heat can get from the glass globe to the thermometer—(1) By radiation across the intervening space; (2) by communicating an increase of motion to the molecules of the gas, which carry it to the thermometer. It is quite conceivable that a considerable part, especially in the case of heat of low refrangibility, may be transferred by "carriage," as I will call it to distinguish it from convection, which is different, and yet that we should not perceive much diminution of transference and consequently much diminution of rate of rise with increased exhaustion, so long as we work with ordinary exhaustions up to 1 millimeter or so. For if, on the one hand, there are fewer molecules impinging on the warm body (which is adverse to the carriage of heat), yet, on the other, the mean length of path between collisions is increased, so that the augumented motion is carried further. The number of steps by which the temperature passes from the warmer to the cooler body is diminished, and accordingly the value of each step is increased. Hence the increase in the difference of velocity before and after impact may make up for the diminution in the number of molecules impinging. It is, therefore, conceivable that it may not be till such high exhaustions are reached that the mean length of path between collisions becomes comparable with the diameter of the case, that further exhaustion produces a notable fall in the rate at which heat is conveyed from the case to the thermometer.

The above experiments show that there *is* a notable fall, a reduction of pressure from 5 M. to 2 M. producing twice as much fall in the rate as is obtained by the whole exhaustion from 760 millimeters to 1 millimeter. We may legitimately infer that each additional diminution of a millionth would produce a still greater retardation of cooling, so that in such vacua as exist in planetary space, the loss of heat—which in that case would only take place by radiation—would be exceedingly slow.—*Chem. News.*

* Abstract of a paper read before the Royal Society, Dec. 16, 1880.

THE FATAL DOSE OF CARBON OXIDE FOR VARIOUS ANIMALS.

By M. GRÉHANT.

AIR containing one-three-hundredth of its volume of carbon oxide proved fatal to a dog when inhaled for fifty minutes. With another dog of the same size the fatal dose was one two-hundred-and-fiftieth. A rabbit resisted various proportions up to one-sixtieth. A sparrow perished with one-five-hundredth.

CAUSE OF DIPHTHERIA IN THE FAMILY OF SAMUEL CRUMP, ESQ., MONTCLAIR, N. J.

By J. W. PINKHAM, M.D., Montclair, N. J.

ALTHOUGH I saw but little of the cases referred to below, having had under my care only the fourth child after the third day of his attack, I have had an opportunity to collect some instructive facts connected with the matter, which I think will be of general interest.

Diphtheria in Montclair has been a thing of rare occurrence, only thirteen fatal cases having been recorded in the last fourteen years.

At the time the disease showed itself in Mr. Crump's family there were no other cases in town, and I believe there have been no cases since.

Mr. Crump's residence is situated on a hillside, about three hundred feet above the sea level. The ground is dry and slopes toward the east. The house is exposed on all sides to the direct rays of the sun. The cellar is dry.

The plumbing of the house is confined to the kitchen, the laundry, the bathroom, and one bedroom on the second floor. Every waste pipe is trapped and every trap is ventilated. The soil pipe extends above the roof, and is supplied with foot ventilation. The cesspool is thoroughly ventilated. Nearly every room in the house is supplied with a separate ventilating shaft. In the opinion of experts the house could not have been unhealthy from sewer gas nor from soil dampness.

The house is warmed by a hot-air furnace, called the Gould Hygienic Furnace, the peculiarity of which is that it presents a large radiating surface and thus does not overheat the air. Mr. Crump, in order still further to insure himself against the evils of overheated air, caused his furnace (*i. e.*, the radiating surface) to be covered with a coating of clay; and, to prevent the air from becoming too dry, a large evaporating dish was placed in the hot-air chamber.

The household consisted of thirteen members, seven adults and six children. The adults were Mr. and Mrs. C., two lady relatives, and three servants. The children were all under eleven years of age. The family was an unusually healthy one, and no member of it, so far as can be ascertained, had been exposed in any way to the contagion of diphtheria. There had been no case of the disease in the vicinity of Mr. Crump's house for many years, so far as known. Twenty-seven feet from the cold-air box which supplies the above-mentioned furnace with air, is the fence which separates Mr. Crump's lot from the adjoining premises. This cold-air box was, previous to the attack, on a level with the ground, and presented in transverse section an area of two square feet.

On the eighth day of December, 1880, there were spread on the grounds of the above-named adjoining premises the contents of a cemented pit, which, during the summer, had received the waste from the stable and the kitchen. At the time it was spread it was noticed that the odor was very bad, and it was particularly noticed by those who passed along the carriage-way between Mr. Crump's house and the place on which the refuse was spread.

Now, keeping in mind the relative position of the two places, viz., that Mr. Crump's lies to the east and is somewhat lower, let us glance at the following table taken from the carefully kept meteorological record of William A. Whitehead, Esq., of Newark:

Dec., 1880.	Temperature.			Wind.	State of Weather.
	Min.	Max.	Mean.		
8.....	14	27	20	N.N.W.	
9.....	11	12	11+	W.	
10.....	6	23	15	N.W.	
11.....	6	23	15	N. to W.	
12.....	19	37	28	W.N.W.	
13.....	32	39	35	W.S.W.	Cloudy.
14.....	30	40	35	W.	Fair.
15	32	39	35	W.S.W.	Clouds and rain.
16....	33	38	35	W.S.W.	Clouds and rain.
17.....	21	30	25	N.W.	Fair.
18	23	32	27	W.N.W.	Fair.
19.. ..	19	33	26	N.N.W.	Fair.
20.....	23	31	27	N.	Cloudy
21... ..	27	32	30	N.E.	

It will be seen that the thermometer remained below the freezing point until the 13th, when it reached 39°. On this day it was cloudy and the wind was westerly. On the 14th the temperature was 40°+, with the wind directly west. On the 15th it was 39°+, wind westerly, with clouds and rain. On the 16th it was 38°+, wind westerly, with clouds and rain.

Thus, for nearly five days the temperature was considerably above freezing nearly all the time, the wind was constantly from a westerly direction, and during the two days when the temperature was highest there were clouds and rain. During these warm, moist days the odor from the refuse described above was very marked, and as its source was only twenty-seven feet from the entrance to Mr. Crump's cold-air supply-box, and as the wind was constantly in the direction toward Mr. Crump's house, the gases which made themselves so perceptible in the neighborhood must have been drawn into the furnace with the inflowing air, and must have been distributed to that part of the house heated by the furnace.

Mr. and Mrs. Crump and the children slept in bedrooms warmed by this heated air from the furnace.

The remaining five members of the family occupied bedrooms which were not so warmed. On the 22d of December, one of the children, aged six years, after two or three days' illness, presented unmistakable evidences of diphtheria, and died on the 26th. A second child was attacked on the 26th, a third child and Mrs. Crump on the 27th, and a fourth child on the 29th. The second and third child died on the 31st of December and the 1st of January respectively. Mrs. Crump and the fourth child recovered. In the course of seven days, of the eight persons who slept in the furnace-warmed rooms, five were attacked with diphtheria, three cases terminating fatally. The remaining members of the household, five in number, who occupied rooms not supplied with registers, all escaped.

It is worthy of notice that of all the attendants, physicians, nurses, and friends who were brought into close relation with the sick day and night for more than ten days, with possibly one exception, not a person contracted the disease.

The exception referred to was that of a colored nurse, the brevity of whose attack (two or three days) makes it fairly questionable whether it was diphtheria she had, or some affection which simulates it. Now, when we consider the immunity of so many people, for so long a time, and so fully exposed to the disease in so malignant a form, does it seem probable that one of these children should have contracted it from a person so slightly affected as to be unconscious of illness, or should have come in contact with the poison in a place where the disease did not exist, and have transmitted it in so short a time to so many members of the family?

On the other hand, when we consider the close proximity to the large cold-air box of a mass of putrefying animal and vegetable matter, the effluvia from which were, for five days, constantly mingled with the air which, in a continual stream, passed through the hot-air chamber of a furnace which heated it, we may fairly suppose, to a degree not too great to do otherwise than render more active the already poisonous gases with which it was loaded, when we take into account the large evaporating dish contained in this hot-air chamber, which supplied an abundance of moisture, and the still more important fact that, of those most exposed to this air from the furnace, five out of eight were seized with diphtheria in the space of one week, while the five who were least exposed all escaped, does it not seem probable, whatever views we may entertain concerning bacteria and specific germs, that we have in these poisonous effluvia the essential cause of the disease in this particular instance?—*Med. Record.*

NATURAL BONE-SETTING.

THE career of the Italian female bone-setter, Regina Dal Cin, who has just returned to her native hills after a triumphal year of residence in this country, is like a bit of the surgery of a past age, revived from its sleep of a hundred years, to give us a demonstration of the manner in which surgery was divided into fragments, and illiterate specialists itinerated from place to place seeking occupation. The stone-cutting expeditions through Europe of Friar Jacques strongly resemble the bone-setting journeys of Madame Dal Cin to Vienna, Trieste, and America. Even the record of the dirty monk that "most of the Parisians looked upon him as a physician sent from heaven for the relief of mankind," is equaled by the claims for a special heaven-endowment made for the illiterate peasant woman. A native of an obscure village in the north of Italy, the daughter of an innkeeper, without education, unable even to read in her own language, self-instructed, she has acquired such tact and facility in the manipulation of joints which have been the subject of chronic diseases, that, in selected cases she has been able to accomplish most excellent curative results. Her local reputation in Italy attracted the attention of an officer of high rank in the U. S. Navy, who took his child, the subject, as was believed, of an incurable joint-disease, to her for treatment. The child having been greatly benefited, the case became the occasion of a highly wrought article descriptive of the powers of the *manipulatiste*, from the pen of the father, in one of the most popular monthly magazines. A wealthy and influential family of Brooklyn, one of whose daughters was crippled from spinal and joint affections, attracted by her reputed powers, took their daughter to Italy and placed her under the care of this person, and eventually persuaded her to return to this country with them, where her stay was prolonged more than a year. Her arrival was heralded by long articles written by a clergyman and published in the daily papers, in which her supposed wonderful, mysterious, and God-given gifts of bone-setting were set forth with all the details which a vivid imagination and a good command of adjectives made possible. Large numbers of those who were halt and crippled from chronic hip and knee diseases were taken to her. As in the case of most others of these less pretentious natural bone-setters, who are found scattered more or less thickly about the country, ignorant of anatomical knowledge, and innocent of even the meaning of the word pathology, the invariable pathology of the cases brought to this woman, as she claimed, was that a bone was "out," and that when by her manipulations the bone was restored to its place, a cure would be effected.

Her method of treatment was to keep the affected joint continuously poulticed for from ten days to two weeks with a poultice of marsh-mallows; during this time gentle movements and firm rubbings were daily impressed upon the joint, and the expectation of the patient constantly excited as to the time when the final maneuver was to be made by means of which the distorted bone was to be put back in its place. After sufficient of this preparatory treatment had been made, the final *coup de grace* was effected by a series of quick movements and an exclamation from the operatress that at last it was done! As a rule, all her manipulations, even her final climacteric performances, were nearly painless. Great improvement in the usefulness of the affected joints resulted in many cases. This woman, now about sixty years of age, is said to be modest, kind, and gentle in her manners, and is undoubtedly firmly and honestly persuaded that the conditions which she imagines to be present in her patients really exist; for how otherwise explain the success of her treatment, which has been so great as to secure for her, after repeated legal prosecution for practicing without qualifications, an official decree from the Minister of the Interior in the Kingdom of Italy, authorizing her to treat dislocations, fractures, and hip disease!

A review of her methods shows that they are as perfect as if they had been devised by one profoundly versed in psychology and pathology. The expectation of the patient, his confidence in the result, and the co-operation of his will are all enlisted by them. She probably never heard of Tuke on "The Influence of the Mind upon the Body," but she could not have done more wisely if she had closely studied it. She believes in herself as thoroughly as Bonaparte did in his "Star of Destiny:" to her every case is an engagement, and every patient she makes an Old Guard. The real condition of the joints in the manipulation of which her success is so signal, can very rarely be that of dislocation or even of subluxation.

Those who have read that most delightful and profitable little book of Wharton P. Hood, entitled "On Bone-Setting," will retain a vivid remembrance of the clear manner in which he demonstrates the function of persistent bands of adhesion, both extra and intra-articular, in producing permanent lameness of joints after all inflammation has subsided. The profession owes a debt of gratitude to Dr. Hood that he availed himself of the opportunity to study the methods of one of the ablest of bone-setters, and that, having pursued his studies after scientific methods, he has given us the results as he has. These cases of lame joints confront every practitioner continually; too often they constitute an *opprobrium chirurgicum*; and when, after having been long unrelieved through the want of skill or attention of the educated practitioner, they are cured by the manipulations of a bone-setter, they bring scientific surgery into discredit. It is our conviction that in the majority of cases of stiff joints the obstacle to motion exists less in intra-articular effusions and adhesions than it does in the changes which the extra-articular structures have undergone; stiffened and adherent muscles and ligaments, contracted fasciæ, tendons and sheaths inseparably blended, conditions which have developed from old inflammations about a joint or from prolonged disuse after bruises or other injuries, these are the chief causes of disability. How admirably the emollient poultices, the rubbings, and the movings practiced by the Italian woman are adapted to promote the absorption of effusions, the stretching and rupture of adhesions, and the restoration of tone to debilitated structures! It is true that no new principle, no new method, is found in her practice. She is but a skillful *masseur*. The reason why physicians in general so often fail to relieve the cases in question, and so permit them to fall into the hands of empirics, is that these details of poulticing and rubbing and moving demand a degree of patience and devotion to trifling details which is possessed by but few. As in so many other things, the brilliant successes of such a person as Madame Dal Cin alone are heard of, while of the many failures and occasional disasters nothing is said. We are cognizant of one case in which she reawakened in a hip joint acute inflammation, which terminated in abscess and necrosis. The scientific surgeon weighing carefully all the elements of the problem, which each case that comes before him presents, will determine what cases are the proper ones to submit to manipulations, and what to leave undisturbed. In his hands the same brilliant successes will be secured by the same methods in the one class of cases, while in the other disasters will be prevented. Under the guidance of the educated surgeon, Madame Dal Cin and such as she might do work of yet greater value. The methods of the natural bone-setter, as in the case of the English Hutton and the Italian Dal Cin, may sometimes repay the consideration of the educated surgeon. It would be a mistake to always ignore them, or to invariably dismiss their work with a sneer and the epithet of quackery.—*Annals of Anat. and Surg.*

EFFERVESCENT BEVERAGES.

A CORRESPONDENT of the London *Chemist and Druggist* supplies the following formulæ:

GINGER BEER.

Brown sugar	2 pounds.
Boiling water	2 gallons.
Cream of tartar	1 ounce.
Bruised ginger root	2 ounces.

Infuse the ginger in the boiling water, add your sugar and cream of tartar; when lukewarm strain; then add half pint good yeast. Let it stand all night, then bottle; if you desire, you can add one lemon and the white of an egg to fine it.

LEMON BEER.

Boiling water	1 gallon.
Lemon, sliced	1
Ginger, bruised	1 ounce.
Yeast	1 teacupful.
Sugar	1 pound.

Let it stand 12 to 20 hours, and it is ready to be bottled.

HOP BEER.

Water	5 quarts.
Hops	6 ounces.

Boil three hours, strain the liquor, add

Water	5 quarts.
Bruised ginger	4 ounces.

and boil a little longer, strain, and add 4 pounds of sugar, and when milk-warm, 1 pint of yeast. Let it ferment; in 24 hours it is ready for bottling.

SPRUCE BEER.

Hops	2 ounces.
Chip sassafras	2 "
Water	10 gallons.

Boil half an hour, strain, and add

Brown sugar	7 pounds.
Essence of spruce	1 ounce.
Essence of ginger	1 "
Ground pimento	½ "

Put into a cask, and cool, add 1½ pints yeast, let stand 24 hours, fine, draw it off to bottle.

CAMPHOR PRODUCTION.

SINCE the abolition of the camphor monopoly, trading in this article is equally permitted to Chinese and Europeans. Nevertheless, the purchase of camphor in the interior, owing to the peculiar difficulties connected with it, is surrendered by the foreigners exclusively to the Chinese. The camphor tree occurs on the hills of the interior in large forests, which are inhabited by wild tribes, who annually kill a number of the Chinese engaged in felling the trees. Each year it is necessary to penetrate further into the interior, because *no new trees are planted* in place of those cut down. While this short-sighted method will sooner or later excite a fatal influence upon the camphor trade, it has, on the other hand, the advantage of causing a more rapid civilization of the island, since the wild tribes are continually pushed further inland into the central and inhospitable mountainous regions. The class of Chinese who are engaged in the production of camphor may be designated as the scum of the Chinese nation, being altogether composed of persons who prefer the dangers of the wilderness to law and order. In the neighborhood of Yokohama murders of camphor tree cutters are said to be of daily occurrence. The export of camphor in 1878 amounted to 13,305 piculs (1 picul = 133⅓ lb.), being 2 per cent. more than the export in 1877, 53 per cent. over that of 1876, and 84 per cent. over that of 1875. The increase was chiefly caused by the fact that merchants upon Formosa found it more advantageous to remit payment to the Hong Kong importer in form of camphor than in funds. According to the latest custom reports, the price of camphor in Formosa is $9 to $10 per picul, and in Hong Kong, $18 to $20, but owing to the great loss, which sometimes amounts to 20 per cent., and the expenses of freight, commission, etc., the profit is much less than would appear from these figures.—*Oesterr. Monatschr. f. d. Orient.*

THE SACERDOTAL PALACES OF MICTLAN, IN MEXICO.

THE fertile valley of Oaxaca was anciently the cradle of a nation far advanced in civilization, the Tzapotecs, or, as they would be called in their own language—which has no similarity either to the Aztec or to the Maya—the Didsasa. Their political capital was Teotzapotlan, called at the present time Zachila and their religious capital was Mictlan, or Mitta, as it is called. Mictlan signifies place of the dead, because it is at Mictlan that the tombs of the Tzapotec kings are found.

In this sacred city this curious people have left to us, in the ruins of a series of sacerdotal palaces of marvelous architecture, an evidence of their advanced civilization, unfortunately destroyed in the midst of its development by the brutality of the conquering Spaniards.

FIG. 1.—RUINS OF MICTLAN, MEXICO.—THE HALL OF THE SIX COLUMNS.

It is ever to be regretted that the Spaniards have destroyed all the documents concerning the history of the people who were able to erect such splendid monuments. They have only preserved the names of their last two kings, but in a very corrupt form. I have, however, succeeded in restoring the veritable form of the two names, which are Aztec and not Tzapotec. The next to the last king was called by the Spanish authors Cosijoëza, and the last one Cosijopi. The first name is Xochiquetzal, and the last Xochiquetzalpilli, which means son of Xochiquetzal. Pilli in Aztec signifies son.

The ruins of Mictlan are thought by Americans to surpass in artistic value all other monuments upon the American Continent. This opinion is well founded.

The different fronts of the palace are decorated in an admirable and original manner. The exterior casing of the walls consists of a mosaic of finely hewn stones. This curious mosaic is disposed in panels which exhibit the various and ingeniously enchased designs.

The engraving (Fig. 1), from a photograph taken in Mitta in 1876, represents the famous hall of the six columns, which is found in the best preserved palace. The girders of the roof have all disappeared. The walls of the hall were anciently painted red. The paint was applied upon a very thin layer of stucco. I have ascertained that there are three superposed layers of stucco, each showing the same red color, similar to the red of Pompeii. This proves that the painting of the hall was renewed three times by the ancient inhabitants. We have here an incontestable evidence of the great antiquity of these edifices.

The six monolithic columns have neither base nor capital, but the shaft shows the "entasis," or the almost imperceptible swelling found in the Greek columns.

The Tzapotec race extended its domain as far as the Isthmus of Tehuantepec. The inhabitants of the city of Tehuantepec are distinguished in our day by their fine physique, the vivacity of their character, and the beautiful costumes of their women. Their costumes are picturesque and varied according to the occasion.

The photograph that we have chosen for our second engraving (Fig. 2) represents two young ladies in ball costume.

The greatest magnificence is displayed by the Indians of Tehuantepec on the occasion of a ball. They adorn themselves with their most beautiful garments, and cover themselves with gold ornaments sometimes of great value. The dazzling splendor of their costumes, of such brilliant colors, and their dignified deportment give them a truly royal appearance. I have never seen among any people such rich and beautiful costumes as those of the Indians of Tehuantepec, and they deserve the fame which they possess throughout Mexico.—*T. Maler, in La Nature.*

FIG. 2.—LADIES OF TEHUANTEPEC IN BALL COSTUME.

SUGAR MAKING IN CUBA.

THE West Indies is most positively the home of the sugar-cane, for here it grows in greater luxuriance, and contains ten per cent more saccharine matter, than that raised on any other portion of the globe.

Its stalks are from eight to ten feet high, divided into sections of six or eight inches in length, the shortest ones toward the base, by dark green rings. At these intervals the long sword-like leaves shoot out from the stem; also at these rings appear the small sprouts from which the plant is generated, and that grow on opposite sides of the stalk.

The first thing in the cultivation of sugar-cane is, of course, to prepare the soil for the reception of the plants, and it is done by plowing the ground in drills about six feet apart. In olden times this operation, which was called "cane-holing," was performed by manual labor with a hoe; the laborer scraping out a cavity to a depth of ten or twelve inches, and some four feet square. This was a long and tedious task, requiring a great many men; seventy-five holes was considered a fair day's work for one man.

RAISING CANE.

In the drills is placed a very little "*metasse*," which is the pulp of the sugar-cane after passing through the mill and is left to decay, forming an excellent manure for strengthening the land. Next the sprouts are laid; these are generally the four or five upper joints of the cane, as they contain much less saccharine matter than the lower portion and therefore can be used at less expense than though the whole stock was taken. It is then covered, and from here on till almost time for cutting, which is from six to ten months, a continual harrowing or hoeing must be kept up to free the ground from weeds.

A more minute description of the cane and the manner in which the saccharine matter is secreted within it may enable the reader to more fully understand, in this short article, the process by which sugar is made. Each section, which is separated one from another by the rings before mentioned, contains parallel tubes extending lengthwise of the stalk; these are filled with what is termed cane-juice, or the real material that is the foundation of the article of which we are in quest. It contains one-fifth sugar to four-fifths water. This standard of course varies with the age of the plant and the locality in which it is grown. The cane fully matured contains a much larger secretion of sugar than that which has not yet attained its growth.

Besides the juice-cells there are numerous sap-vessels lying directly beneath the hard covering or bark of the cane; these are the life of the plant, and upon their contents it continually feeds, and it is these same sap-vessels which contain the impurities which cause the sugar-boiler such great difficulty to separate from the pure juice.

I was surprised to behold the magnitude of the machinery employed upon the estate, in the crushing, clarifying, and boiling of cane and sap. The crusher, which is by far the heaviest, and, aside from the engine, the most expensive of the machinery, was in a building entirely by itself. It consists of—beside the necessary gearing to support them—two immense cylinder rollers, thirty-eight inches in diameter and six feet long. A slight idea of the enormous strength of this machine may be obtained when I state that the weight of the "gudgeons" to the upper cylinder is twenty-eight hundred pounds.

EXTRACTING THE JUICE.

Between these ponderous rollers, which turn at the speed of two and a half revolutions per minute, is passed the cane, after being carefully stripped of all its leaves, which, if pressed, cause a green tinge to be communicated to the liquor, and such is the force brought to bear upon it that it is discharged from the cylinders so dry that, upon being exposed to the sun for an hour, would form excellent fuel. Indeed it is used for such a purpose when not required for manure.

In feeding this "crusher," the stalks are laid lengthwise on a long table, the top of which is provided with a series of rollers that, in revolving, carries the cane to the cylinders in such quantities and with such speed as the machine can receive it. Directly beneath the "crusher" is placed three metallic strainers, through which the newly extracted fluid passes into a large copper or lead-lined tank. These screens serve to arrest such particles of detached cane or other bulky impurities which may have adhered to the stalk. These strainers are so arranged as to be easily and quickly removed in order to cleanse them. From the tank the juice immediately passes into an immense boiler capable of containing five hundred gallons. Any delay in the transit causes great detriment to the quality of the sugar, as the impurities which the newly expressed juice contains are highly fermentations in character, and a few hours' detention would be sufficient for them to destroy the whole batch.

The temperature of the fluid must be raised as quickly as possible to at least 160° F., and kept at that pitch about twenty-five minutes, until a thick scum arises, which is immediately taken off; then three tumblers of lime are added, after which the entire quantity of liquor is conveyed through tubes of metal into a course of three filters charged with animal charcoal.

These filters are composed of a series of cylindrical copper vessels, each having a double bottom, and being hermetically closed at the top. Into the upper part of the first vessel is introduced a pipe for the admission of the sirup, which is made to descend from a sufficient height to force the fluid rapidly through the charcoal, and is received by the space between the two bottoms. Here it enters another pipe which conveys it to the upper part of the second filter, placed close by. Thus it continues through the whole series, until it is at last drawn off by a cock placed for the purpose in the last vessel.

Each of the cylinders is six feet high and three feet in diameter. They work for five or six days without cleaning; and the charcoal is never removed from them, but when its powers require to be restored, boiling water is introduced for the purpose of washing away as much as possible the sirup remaining in the interstices. The sweet liquid which comes away is poured into the evaporating vessels, while the filters are put into some warm place, that fermentation may ensue. It is stated that this fermentation is completely terminated after twenty-four or thirty-six hours. In this way the organic matters which had neutralized the decolorating powers of the charcoal are destroyed, and to restore its properties nothing more is required but an effective washing. This is done by passing hot water through the filters, until it comes away perfectly clear.

After passing through these filters, the juice is considered pure. It is now supposed to be wholly free from the impurities caused by the presence of albumen, caseine, and the salts of potash and soda, which are found in the newly-expressed juice. The purified liquor is next conveyed by means of a copper trough to four copper kettles, successively, the first one directly over a fire, the heat of which is raised to nearly 212° F. The next kettle is placed upon the same furnace, but a little removed from the fire, and so on until it reaches the fourth, which is some distance away, but still receiving considerable heat from the same blast.

THE BOILING PROCESSES.

The liquor in the first kettle is allowed to boil briskly till it reaches a certain stage—noticeable by the experienced boiler by its peculiar smell. The acuteness of the olfactory organs of the sugar boiler is what they most particularly pride themselves upon. It then passes into the second kettle, and successively to the fourth, which last is of a different shape from the others, much resembling half a cylinder. It is of sufficient proportions to hold at least four hundred gallons, being about five feet long, and quite wide and deep. In it revolved slowly a miniature water wheel, or a wheel constructed upon the same principle, with metallic "buckets."

This continually agitated the fast cooling sirup, and caused it to be brought to a state of granulation; it remains in this metallic receptacle until it is plainly seen to be graining or separating into minute particles. It is then poured into casks, with small holes pierced through the bottom and

stopped with sugar cane, thus allowing the molasses to drain into a tank or cistern over which they are placed.

After they have remained thus for a few hours, a quantity of clear sugar and water is mixed to the consistency of thick sirup, and is poured upon the top of the sugar, which, trickling down through its particles, carries with it what little molasses has not been able to find its way out unaided—leaving the sugar in the state called "Muscovado." This is the coarsest brown sugar which we receive in this country.

Great care and strict attention to cleanliness must be maintained throughout the apartments in which the sap is confined, and no utensils of wood can be used, as they, being more or less porous, would absorb some of the juice, and in a short time become acid, which would instantly taint any future "batch" of sirup with which they came in contact.

BEST SOIL FOR SUGARS.

Molasses is that portion of the sirup which refuses to "granulate," and is now in Cuba become nearly as extensive an article of export as the sugar itself. Respecting the difference in the yield of the cane grown in different localities and in various soils, it is a well-known fact among all sugar planters that too-highly manured ground will produce cane containing but little saccharine matter, or about one part sugar to seven water.

To be sure the plant grows very tall and rank, but that is all. This specimen is called by the negroes "water" or "washie" cane. That grown inland or away from the sea makes sugar of a much finer quality than the cane grown upon the coast. It is a noticeable fact that the latter contains large quantities of chloride of sodium. The presence of this salt in the juice of this plant is difficult to account for, and I have never yet heard it satisfactorily explained.

The soil chosen for planting is the black loam; it is considered much better than the red, clayey earth which is found in various parts of the island. This latter ground is chosen for the growing of coffee, a considerable quantity of which is produced in Cuba. It is estimated that five hundred gallons of juice of perfectly ripe cane will yield three hundred pounds of "Muscovado."

After the sugar in the hogsheads has drained perfectly dry, they are filled, to make up for the loss of drainage, headed up, and are then ready for shipment.

The casks and boxes which are sometimes used are made entirely in the United States—the greater part of them coming from Maine. They are sent out in a "knock-down" shape and are called "shooks." Every plantation has its resident cooper, who expeditiously puts together the casks ready for their load. The hogsheads vary in size from thirty-six to thirty-eight inches across the "head;" the latter capable of holding an average of eighteen hundredweight of sugar. "Tierces," twenty-six inch head, are sometimes used, but only by those shippers who remove the sugar from the hogsheads to place it in them for the accommodation of vessels with "small storage." Boxes are not very often used at the present time, they being so much more difficult to handle than casks.

PRICES OF FREIGHTING.

When the planter has sufficiently cured his sugar, he dispatches it at once to the seaports, where it is placed in the hands of a commission merchant to dispose of; but its stay in the cities is seldom long, for there are always plenty of buyers waiting to trade for it and transport it to different parts of the world.

The prices paid for freighting vary with the quantity of sugar on hand and the number of vessels lying in port. The average price from the north side of the Island of Cuba to any American port north of Cape Hatteras and south of Portland, Maine, is four dollars and a half per hogshead, though sometimes as high as seven dollars is paid and as low as three and a half accepted. This is, of course, for full sized hogsheads; tierces are generally about two-thirds of the price of a cask.

Vessels often find some trouble in obtaining "small storage," as the shippers quite frequently object to filling tierces for them; in this case, where the captains are obliged to take all thirty-six and thirty-eight inch hogsheads, they are compelled to cut themselves out of from ten to thirty casks, according to the size and build of the vessel, the freight on which is, of course, quite a little item.

The cause of their being obliged to leave behind them such an amount of cargo will be readily seen, when one takes into consideration the formation of a vessel's hull. The "sheer" of the bow, of course, brings the sides closer together until they meet the "cut-water." In an ordinarily built vessel of four hundred tons, the usual size of those running in this trade, there is a space of at least eight feet long from the stern aft into which it would be impossible to crowd a full-sized hogshead.

MANNER OF STOWAGE.

Now to take a look at the stern, it is much more flaring; to be sure there is considerable "sheer" of the "counter," but casks will stow pretty well aft provided one could fill up the bows of his vessel with small stowage; if not to load her all she will hold aft, would settle her stern at least a foot deeper than the head, which would cause the vessel "to handle" so badly, especially when sailing "by the wind," as to be almost unmanageable. This is why that, when tierces cannot be obtained, captains are unable to take a full freight.

In loading a vessel with sugar, the first thing to be done is to measure off the floor, which the officer, who is generally the second mate, does with a stave and a piece of chalk, commencing directly under the "main hatch" and working forward and aft. When he finds exactly where his foremost and aftermost casks are to lie he rolls them into place, and works from both ends of the vessel toward the "hatch."

A correct measurement must be made in this calculation, as an inch lacking in space would cause him considerable trouble in placing his last hogshead. The next tier is commenced in the same way, but measurement is unnecessary, as the lower ones form a gauge. Eight casks athwart ships, or from side to side, is generally the number carried in a four or five hundred ton vessel, that is on all but the ground tier, which has two less. Five hundred hogsheads would be considered a good freight for a four hundred ton vessel. The whole cargo must be stowed below decks, as the nature of sugar is so deliquescent that to carry any as a deck load would be almost sure to secure the destruction of that portion. The casks in which molasses is carried are much more carefully made and compactly built than those in which sugar is stowed.

In fact a barrel made to contain molasses must be tighter than one to hold water, for molasses will find its way through a smaller seam than any other liquid. They, unlike sugar casks, are almost entirely made and put together in the United States, and are sent out in the shape of "empties."

After the molasses has been drained from the sugar, it receives another boiling, in order to separate from it whatever little crystallizable matter may remain. It is then run into casks holding sixty to eighty gallons, and is ready for shipment.

The work of "stowing" a cargo of molasses is altogether different from one of sugar. The first thing to be done is to procure fifteen or twenty empty casks. These are stored bung up, with as little "dunnage"* around them as possible, for should a quantity be used, it is almost certain to move about and allow the casks sufficient play to work adrift. While one portion of the men are employed in placing the empty casks, the remainder are busy in erecting a staging extending from and a little above the "rail" over the "main hatch."

Next is placed upon the staging a large tub with a hole in the center of the bottom, to which is attached long canvas hose; the end of this is furnished with a curved nozzle. This nozzle is placed in one of the empty casks already stored in the hold. A full cask is hoisted from the "lighter" or wharf and placed upon the tub, the bung is then knocked out and the molasses allowed to run into the huge tunnel, and by the hose is conveyed into one of the casks already in the vessel.

After a hogshead is emptied it is immediately lowered into the hold, and stored to await refilling. They are never bunged up, for if they were the molasses in "working" would burst the casks and spill itself in the hold. Thus great care must be used in loading so that none of the barrels can turn over. The price paid for the transportation of molasses is from a dollar to a dollar and a half less per hogshead than for sugar; but vessels can always carry a "deck load," as a little salt water will never hurt molasses.

A few years ago a vessel was built, her entire hold comprising a huge tank of sheet iron. It was thought by some merchants that a great saving would be made by carrying molasses in "bulk;" but sailors regarded the idea with little favor, and it proved as they feared. The vessel, when loaded with this "shifting cargo," became almost unmanageable, and after the first trip she was used for some other business than that of a molasses "droger."—*Commercial Bulletin.*

* Wood used in laying a flooring or checking a cargo.

SOILING STOCK.

A WRITER in a recent number of the *Milch Zeitung* says that his own experience of fifty years has taught him that regular soiling of cattle is best for the farmer and for his fields, bringing in greater profit and maintaining the fertility of the land at a higher point—that twice as much fodder can be produced on a given surface when the forage plant is allowed to grow as a cultivated crop, and reach a certain degree of maturity, than when, as in pasture, it is continually cropped off and trodden down. He believes, as do all the best German writers on the subject, that the most successful system of agriculture in the long run is that in which a large quantity of stock is kept and fed well, and a careful rotation of crops is followed, in which the same crop is never put twice in succession on the same land. The soiling system makes it easier to carry out the second part of this programme, and the greater variety of crops that can be raised on a long rotation provides a greater variety of fodder for the stock, so that these two features of the best modern agricultural practice work admirably together. The soiling system provides a more uniform ration in respect to quantity, and avoids much loss of manure. It may be pretty safely affirmed that the droppings of cattle in the pasture are more than half wasted by drying in the sun, or by too strong dosing with manure in isolated spots here and there. Where land is cheap and abundant, and cannot be profitably cultivated and carried up to a high degree of fertility, pasturage over a large portion of the farm may be allowed, but when high farming pays, pasture land is a poor investment, and may eat up a large part of the profits from the cultivated fields.

THE HAY CROP.

THE best paying crop the farmer can raise is hay; this, as a general rule. A good grass farm admits of much and good stock, hence a large amount of manure and good crops of grain, corn, and potatoes. It is an oft-repeated maxim that the farmer had better buy than sell hay, meaning that selling hay from the farm impoverishes it. So it does, and in selling grain and potatoes, twice as rapidly. As a general rule, it is better to sell hay than to use it upon the farm and then sell the crop it nourishes. One of the paying crops this year is hay, especially for the farmers living near the city. The demand for hay in our cities and the substitution of dairying and stock raising for other branches of farming in the best hay-producing localities has caused hay to maintain a higher proportionate price than many other farm products. Hence hay is the best crop farmers can raise under any circumstances, and more especially when the situation favors him, as near a market and good grass land. In choosing a farm, one of the chief requisites should be a portion adapted to the growing of a good quality of hay without the liability of soon "running out" and involving the necessity of re-seeding every few years. A permanent meadow on a farm is a mine of wealth that will pay better dividends than some that purport to yield the precious metals. Much grass land that is not especially moist, but dry enough to grow, when plowed, good crops of corn and grass, may be made to yield increasing crops for a term of years by top dressing. Experiments have shown that none of our chief farm crops make better returns for the use of concentrated commercial fertilizers than hay. Of these, nitrate of soda is among the best, as it has been found that, on application to grass land, it usually much more than repays its cost. The tendency of the salt is downward and enriches the ground deeply, causing the grass to withstand the drought. Chloride of sodium or common salt, plaster, ashes, bone dust, etc., can be used with profit, if judiciously. Top dressing grass lands with stable manure is being practiced by many farmers, and with good results, but it is a mistake to apply coarse manure in the spring to your lands. We lately saw a field that had just been mowed and raked with a horse-rake, where a top dressing of green manure had been applied in the spring; there was considerable straw with the manure, and the manure withal was somewhat limpy from not being sufficiently decomposed, and the consequence was a large part of the manure and straw was disturbed by the rake teeth and mingled with the hay. The effects of the manure upon the growth of the grass was very apparent, and had the manure been allowed to lie in the heap until fall, and the rapid decomposition prevented by forking over occasionally, the disagreeable result of mixing the manure with the hay would have been avoided.—*Ohio Farmer.*

PUT CLOVER ON YOUR LAND.

AN Ohio paper says that, by clovering, hundreds of farms that were about worthless have been rescued from dilapidation and ruin. It is an accepted truism that, as long as "clover will catch," the farm can soon be restored to paying fertility, and, by a good rotation, is even getting more productive and profitable; for after some years of such treatment the land will bear harder farming—that is, two or three crops may succeed a good coat of clover before laying down to clover again. Rough new land should be subdued by the use of large clover. Nothing so effectually rots out stumps, and kills weeds and sprouts, and prepares the land for the plow and good paying crops. Wild, new lands should always have it sown on the first grain crop down. It saves a vast amount of labor, for in a few years it so tames the ground, and clears it of enemies to the plow, that it works like old ground, and is good for full crops. One great error is often fallen into, and that is, following the old tradition that a bushel of clover seed will do for eight acres. That may have been enough to clover land partially when it was new, but whoever aims at getting up his land in a speedy and profitable way should sow a bushel on four acres, so that his land may be thoroughly shaded.

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EXPERIMENTS WITH VACUUM TUBES.

At a meeting of the Philosophical Society of Glasgow on December 22, 1880, I gave a very brief preliminary account of some experiments that I have been making, along with Sir William Thomson, with vacuum tubes. We have sealed up English and German glass tubes with very high vacuums, but without any electrodes; and have obtained very remarkable luminous effects both with the Ruhmkorff coil and also working by means of electrostatic induction. Using an ordinary frictional electric machine, and applying one end of a long vacuum tube to the prime conductor, while the other end of the tube is held in the hand, the tube becomes charged as a double Leyden jar in the following way: one end of the tube, next to the prime conductor, outside positive, inside negative; the other end, inside positive, outside negative. This can be shown by the gold leaf electroscope. The charges seem to be very high and the glass is very frequently perforated. Indeed it is difficult to work with the electric machine in tolerably good order without perforating the glass. While this double Leyden jar is slowly discharged by removing part by part the charges from the outside of the tube, beautiful luminous effects are observed very different from those seen in the ordinary vacuum tubes. We have also obtained curious effects by heating the middle region of the tube so highly that it becomes a semi-conductor. —*J. T. Bottomley, in Nature.*

PHYSICS WITHOUT APPARATUS.

During a lecture course by professors who have at their disposal a complete set of physical apparatus, there are some experiments performed by them which at first sight seem very complicated, but which nevertheless may be repeated by means of very simple objects. There is, for instance, the interesting Lissajous experiment, which consists, as the reader is well aware, in throwing on a screen, by means of the oxyhydrogen lamp, the curves traced by one of the arms of a tuning fork in sonorous vibration. An analogous experiment may be exhibited by means of a common knitting needle. Fix one of the extremities of the needle in a cork to serve as a base; then to the upper free extremity attach a ball of sealing wax, and on this gum a small circle of paper about the diameter of a pea. Now, holding the cork firmly between the fingers of the left hand, cause the needle to sharply vibrate, either by bending it far to one side and then suddenly releasing it, or by striking it smartly with a wooden ruler. The little ball of wax surmounted by paper will be seen to describe a more or less elongated ellipse, or a circle, according to the intensity or the number of vibrations. The phenomenon is very perceptible when care is taken to cause the needle to vibrate under a strong light from a lamp; and, in such a case the persistence of the impression on the retina causes the vibrating wire to form an image which has the appearance of a long and graceful bouquet holder, or a champagne glass (Fig. 1).

Among the experiments sometimes performed to demonstrate molecular attraction, there is one which is executed by means of an apparatus of a peculiar structure; but the same phenomenon may be shown in a much more simple manner, as follows: Having cut two small spheres out of a bottle cork, place them on the surface of water. If one of the balls now carefully be pushed along until it is in quite close proximity to the other, the two will be seen to quickly rush toward each other, just as a bit of iron flies to a magnet when the latter is brought near it. The experiment may be varied by fixing one of the balls to the point of a knife and using it to attract the other ball when floating at a short distance (Fig. 2).

In a former article has been described how an electric spark may be obtained by means of a sheet of paper and a bunch of keys. A writer in a recent number of *Nature* has pointed out a neat method of obtaining the same result by means of a simple apparatus which he calls the "tea-tray electrophorus" (Fig. 3). A common metallic tea-tray is supported on two dry glass goblets. A piece of common brown paper cut so as to be a little smaller than the tray, and with rounded corners, is warmed, laid on the table and rubbed briskly with a piece of India-rubber, or with a clothes brush. It is then laid down for an instant on the tray, and the latter is touched with the hand. The paper is then lifted a few inches above the tray. If at this juncture some person presents his knuckle to the tray he will receive a bright spark, which under favorable circumstances may be a couple of inches long. By simply putting the paper down, touching the tray, and again lifting up the paper, the tray is again charged, and a large number of sparks may be thus drawn one after the other in rapid succession. The paper may be lifted by the hands, but it will be found better if a couple of strips of paper be fixed on with wax to serve as handles, as shown in the figure.

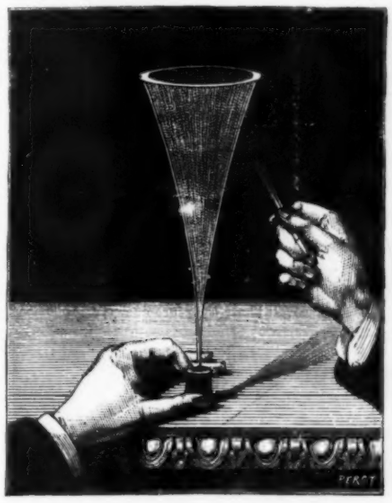

Fig. 1.—EXPERIMENT ON VIBRATION.

The sparks obtained by the tea-tray electrophorus may produce a slight pricking sensation, but to give a regular electric shock will oblige us to store up a charge in a Leyden jar. This important piece of apparatus may be improvised as follows: A round-bottomed glass tumbler is procured—thin glass is preferable—and is filled about three-quarters full of small leaden shot. If shot is not at hand *dry* coal dust will answer, though not so well, and great care must be taken to wipe clean the upper part of the tumbler. Everything must be warm and scrupulously dry. Into the shot is inserted a silver spoon to serve the place of a rod and knob. The tumbler is held, as shown in Fig. 4, by grasping it well in the bottom of the hand, so that the palm may cover the whole of the rounded bottom. Having thus prepared and grasped the improvised Leyden jar, it is to be charged with sparks from the tea tray electrophorus. It should be held with the spoon-handle near to, but not quite touching the edge of the tea-tray, while another person performs the operations of lifting the paper up and putting it down, then touching the tray, then lifting up again, and so on until a dozen sparks have been sent into the jar. On touching the "knob" a smart little shock is experienced in the wrists and elbows, and a short, bright, snapping spark announces the discharge of the jar.

APPLICATION OF THE ELECTRIC LIGHT AT THE ANGERS (FRANCE) SLATE QUARRIES.

In 1832 the Société des Grands Caneaux undertook the first subterranean exploitation of the important slate deposits of Marne-et Loire. After working these nearly fifty years, the quarries, with their galleries running in every direction, have reached an immense depth. The only circumstance that has been found relatively disadvantageous in these underground works is that of the darkness which prevails therein, and which renders the work of the laborers less advantageous and a surveillance of the walls quite difficult. This inconvenience was remedied at first by the substitution of gaslight for the miners' smoky lamps formerly used, and more recently by the application of the electric light, which, indeed, appears to completely solve the problem. The history of these different improvements in lighting is given by M. Blavier, in the *Annales des Mines*, and from this we make the following extracts:

The first gas works were erected in 1847 at the Fresnais Quarry for lighting chamber No. 1, and consisted of one cast-iron retort and one gasometer. When the possibility of sending the gas down to a depth of 650 feet was discovered, and when the superiority of this mode of lighting the subterranean chambers was recognized, the works in the course of the year 1855 were enlarged and equipped with two furnaces of three retorts each—each having two gasometers and the most approved purifying apparatus connected with it. The cost of this establishment was about $6,000. This lighting by gas, however, served only for lighting up the subterranean chambers in a general way, as well as the shaft, but did not suffice for the work of the miner, who was obliged to have constantly beside him his hand lamp. Thus the expense of oil had to be added to that of the gas. The improvement effected by the use of gas, however, was considerable. It allowed the miners to move about without danger, and permitted the superintendents to keep surveillance over the work in progress. The light was, doubtless, a little diffused, but it was sufficient to allow the walls and vaults of the chamber to be seen, and thus it removed that natural apprehension of danger that the miners were apt to feel when working in darkness. The slate companies, however, notwithstanding these improvements and the great cost of the same, began at once to look into the merits of the electric system of lighting as soon as this entered the domain of practice. Some practical tests were made about fifteen years ago, but, owing to a failure to come to terms with the Alliance and other companies, no definite action was taken until 1878. At this period occurred the Paris Exhibition. As a consequence of the economical results obtained with the electric light at this exhibition, and of the improvements introduced therein by the use of the Gramme magneto-electric machine, the Slate Quarry Commission took up the question anew, and decided on the 30th of August, 1878, that an exhaustive trial should be made with these machines at the Fresnais Quarry. After several months spent in determining on the best practical arrangements to adopt for the motor, the lamps, and the electric conductor, the problem was solved by M. Blavier, the engineer, in a manner which left little to be desired. An expansion engine of a nominal sixteen horse power was installed, along with two generators, for driving the six magneto-electric machines necessary for lighting the three subterranean chambers of the quarry. New conducting cables were made, partly of seven No. 18 copper wires, weighing about 5·5 ounces to the foot,

Fig. 2.—EXPERIMENT ON MOLECULAR ATTRACTION.

Fig. 3.—THE TEA TRAY ELECTROPHORUS.

Fig. 4.—THE LEYDEN JAR.